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Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

Amendment 6: Enhancements for High Efficiency WLAN

Prepared by the 802.11 Working Group of the

LAN/MAN Standards Committee
of the
IEEE Computer Society

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Abstract: This amendment defines modifications to both the IEEE 802.11 physical layer (PHY) and the medium access control (MAC) sublayer for high efficiency operation in frequency bands between 1 GHz and 6 GHz.

Keywords: high efficiency, PHY, physical layer, MAC, medium access control, OFDMA, orthogonal frequency division multiple access, wireless local area network, WLAN

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IEEE P802.11ax™/D2.0

Draft STANDARD for Information Technology— Telecommunications and information exchange between systems— Local and metropolitan area networks— Specific requirements

Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications

Amendment 6: Enhancements for High Efficiency WLAN

[This amendment is based on IEEE Std 802.11-2016 amended by IEEE Std 802.11ai-2016, IEEE Std 802.11ah-2016, IEEE P802.11aq/D10.0, IEEE P802.11ak/D4.0 and IEEE P802.11aj/D6.0]

NOTE—The editing instructions contained in this amendment define how to merge the material contained therein into the existing base standard and its amendments to form the comprehensive standard.

The editing instructions are shown in ***bold italic***. Four editing instructions are used: change, delete, insert, and replace. ***Change*** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~strikethrough~~ (to remove old material) and underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new one. Editorial instructions, change markings and this NOTE will not be carried over into future editions because the changes will be incorporated into the base standard.

Editorial Notes

Editor's Note: Editorial Notes in the body of the standard appear like this. They will be removed before publication. They may highlight some issue that the editor has had to address during the implementation of a change. Where there may be any technical impact from an editing issue, the editor will raise a technical letter ballot comment. There is no need for voters to comment on such issues unless they have a specific resolution they wish to present.

Editor's Note: Headings with empty content or Headings preceding editing instructions that modify the contents of the referenced subclause are there to provide context to the reader of this document, they have no other significance.

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Editor's Note: A cumulative status of the versions of this draft is shown below.

Table 1—Draft Status

Draft	Date	Status
D0.1	2016-03-03	Converted to FrameMaker from 16/0024r1 Proposed draft specification
D0.2	2016-06-06	Includes tentative resolutions for most editorials. Includes resolutions for technical comments motioned in May 2016 session.
D0.3	2016-08-11	Includes resolutions for technical comments motioned in July 2016 session.
D0.4	2016-08-26	Included motioned draft changes from July 2016 session and corrected errors.
D0.5	2016-09-30	Included comment resolutions and other changes motioned at the September 2016 session.
D1.0	2016-11-30	Includes all approved changes. Ready for WG ballot.
D1.1	2017-02-09	Includes groundhogs (from 2017-02-02, start of editing), approved changes from the January 2017 session and a few editorials.
D1.2	2017-04-10	Include comment resolution approved during March 2017 session plus a few editorials.
D1.3	2017-05-19	Includes approved changes from May 2017 session plus a few editorials.
D1.4	2017-08-17	Includes approved changes from July 2017 session plus most remaining editorials.
D2.0	2017-10-02	Includes approved changes from September 2017 session.

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3. Definitions, acronyms, and abbreviations

3.2 Definitions specific to IEEE 802.11

Change the following definitions:

20 MHz mask physical layer (PHY) protocol data unit (PPDU): One of the following PPDUs:

a) A Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) PPDU transmitted using the 20 MHz transmit spectral mask defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification).

b) A Clause 18 (Extended Rate PHY (ERP) specification) orthogonal frequency division multiplexing (OFDM) PPDU transmitted using the transmit spectral mask defined in Clause 18 (Extended Rate PHY (ERP) specification).

c) A high throughput (HT) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW20 and the CH_OFFSET parameter equal to CH_OFF_20 transmitted using the 20 MHz transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

d) A very high throughput (VHT) PPDU with TXVECTOR parameter CH_BANDWIDTH equal to CBW20 transmitted using the 20 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

e) A Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) PPDU transmitted by a VHT STA using the transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

f) An HT PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW20 and the CH_OFFSET parameter equal to CH_OFF_20 transmitted by a VHT STA using the 20 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

g) A high efficiency (HE) PPDU with with TXVECTOR parameter CH_BANDWIDTH equal to CBW20 transmitted using the 20 MHz transmit spectral mask defined in Clause 28 (High Efficiency (HE) PHY specification).

h) A Clause 17 PPDU transmitted by an HE STA using the transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

i) A Clause 18 PPDU transmitted by an HE STA using the transmit spectral mask defined in Clause 18 (Extended Rate PHY (ERP) specification).

j) An HT PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW20 and the CH_OFFSET parameter equal to CH_OFF_20 transmitted by an HE STA using the 20 MHz transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

k) A VHT PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW20 transmitted by an HE STA using the 20 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

20 MHz physical layer (PHY) protocol data unit (PPDU): A Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) PPDU, Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) PPDU (when using 20 MHz channel spacing), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification) PPDU, Clause 18 (Extended Rate PHY (ERP) specification) orthogonal frequency division multiplexing (OFDM) PPDU, Clause 19 (High Throughput (HT) PHY specification) 20 MHz high throughput (HT) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW20, or Clause 21 (Very High Throughput (VHT) PHY specification(11ac)) 20 MHz very high throughput (VHT) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW20, or Clause 28 (High Efficiency (HE) PHY specification) 20 MHz high efficiency (HE) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW20.

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40 MHz mask physical layer (PHY) protocol data unit (PPDU): One of the following PPDUs:

a) A 40 MHz high throughput (HT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW40) transmitted using the 40 MHz transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

b) A 40 MHz non-HT duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to NON_HT_CBW40) transmitted by a non-very high throughput (non-VHT) STA using the 40 MHz transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

c) A 40 MHz non-HT duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW40) transmitted by a very high throughput (VHT) STA using the 40 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

d) A 20 MHz HT PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW20 and the CH_OFFSET parameter equal to either CH_OFF_20U or CH_OFF_20L transmitted using the 40 MHz transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

e) A 20 MHz VHT PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW20 transmitted using the 40 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

f) A 40 MHz VHT PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW40 transmitted using the 40 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

g) A 40 MHz HT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW40) transmitted by a VHT STA using the 40 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

h) A 20 MHz non-HT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW20) transmitted using the 40 MHz transmit spectral mask defined in Clause 19 (High Throughput (HT) PHY specification).

i) A 20 MHz non-HT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW20) transmitted by a VHT STA using the 40 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

j) A 40 MHz high efficiency (HE) PPDU with TXVECTOR parameter CH_BANDWIDTH equal to CBW40 transmitted using the 40 MHz transmit spectral mask defined in Clause 28 (High Efficiency (HE) PHY specification).

k) A 40 MHz HT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW40) transmitted by an HE STA using the 40 MHz transmit spectral mask defined in Clause 19.

l) A 40 MHz VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW40) transmitted by an HE STA using the 40 MHz transmit spectral mask defined in Clause 21.

m) A 40 MHz non-HT duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW40) transmitted by an HE STA using the 40 MHz transmit spectral mask defined in Clause 19.

40 MHz physical layer (PHY) protocol data unit (PPDU): A 40 MHz high throughput (HT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to HT_CBW40) or a 40 MHz non-HT duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to NON_HT_CBW40 or TXVECTOR parameter CH_BANDWIDTH equal to CBW40), or a 40 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW40)), or Clause 28 (High Efficiency (HE) PHY specification) 40 MHz high efficiency (HE) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW40.

80 MHz mask physical layer (PHY) protocol data unit (PPDU): ~~A PPDU that is transmitted using the 80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification) and that is one~~ One of the following PPDUs:

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a) An 80 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80) transmitted using the 80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

b) An 80 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80) transmitted using the 80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

c) A 20 MHz non-HT, high throughput (HT), or VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW20) transmitted using the 80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

d) A 40 MHz non-HT duplicate, HT, or VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW40) transmitted using the 80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

e) An 80 MHz high efficiency (HE) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80) transmitted using the 80 MHz transmit spectral mask defined in Clause 28 (High Efficiency (HE) PHY specification).

f) An 80 MHz VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80) transmitted by an HE STA using the 80 MHz transmit spectral mask defined in Clause 21.

g) An 80 MHz non-HT duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80) transmitted by an HE STA using the 80 MHz transmit spectral mask defined in Clause 21.

80 MHz physical layer (PHY) protocol data unit (PPDU): A Clause 21 (Very High Throughput (VHT) PHY specification) 80 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80) or, a Clause 21 (Very High Throughput (VHT) PHY specification) 80 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80), or Clause 28 (High Efficiency (HE) PHY specification) 80 MHz high efficiency (HE) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW80.

160 MHz mask physical layer (PHY) protocol data unit (PPDU): ~~A PPDU that is transmitted using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification(11ac)) and that is one~~ One of the following PPDUs:

a) A 160 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW160) transmitted using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

b) A 160 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW160) transmitted using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

c) A 20 MHz non-HT, high throughput (HT), or VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW20) transmitted using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

d) A 40 MHz non-HT duplicate, HT, or VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW40) transmitted using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

e) An 80 MHz non-HT duplicate or VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80) transmitted using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

f) A 160 MHz high efficiency (HE) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW160) transmitted using the 160 MHz transmit spectral mask defined in Clause 28 (High Efficiency (HE) PHY specification).

g) A 160 MHz VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW160) transmitted by an HE STA using the 160 MHz transmit spectral mask defined in Clause 21.

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h) A 160 MHz non-HT duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW160) transmitted by an HE STA using the 160 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY Specification).

160 MHz physical layer (PHY) protocol data unit (PPDU): A Clause 21 (Very High Throughput (VHT) PHY specification) 160 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW160) or, a Clause 21 (Very High Throughput (VHT) PHY specification) 160 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW160) or Clause 28 (High Efficiency (HE) PHY specification) 160 MHz high efficiency (HE) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW160.

80+80 MHz mask physical layer (PHY) protocol data unit (PPDU): ~~A PPDU that is transmitted using the 80+80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification) and that is one~~ One of the following PPDUs:

a) An 80+80 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80) transmitted using the 80+80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

b) An 80+80 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80) transmitted using the 80+80 MHz transmit spectral mask defined in Clause 21 (Very High Throughput (VHT) PHY specification).

c) An 80+80 MHz high efficiency (HE) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80) transmitted using the 80+80 MHz transmit spectral mask defined in Clause 28 (High Efficiency (HE) PHY specification).

d) An 80+80 MHz VHT PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80) transmitted by an HE STA using the 80+80 MHz transmit spectral mask defined in Clause 21.

e) An 80+80 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80) transmitted by an HE STA using the 80+80 MHz transmit spectral mask defined in Clause 21.

80+80 MHz physical layer (PHY) protocol data unit (PPDU): A Clause 21 (Very High Throughput (VHT) PHY specification) 80+80 MHz very high throughput (VHT) PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80) or, a Clause 21 (Very High Throughput (VHT) PHY specification) 80+80 MHz non-high throughput (non-HT) duplicate PPDU (TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80)) or Clause 28 (High Efficiency (HE) PHY specification) 80+80 MHz high efficiency (HE) PPDU with the TXVECTOR parameter CH_BANDWIDTH equal to CBW80+80.

bandwidth signaling transmitter address (TA): A TA that is used by a very high throughput (VHT) station (STA) or a high efficiency (HE) STA to indicate the presence of additional signaling related to the bandwidth to be used in subsequent transmission in an enhanced distributed channel access (EDCA) transmission opportunity (TXOP). It is ~~represented by~~ the IEEE medium access control (MAC) individual address of the transmitting ~~VHT~~ STA but with the Individual/Group bit set to 1.

user: An individual station or group of stations (STAs) identified by a single receive address (RA) or a STA-ID in HE-SIG-B in the context of single-user multiple input, multiple output (SU-MIMO), multi-user multiple input, multiple output (MU-MIMO), or orthogonal frequency division multiple access (OFDMA).

Insert the following definitions maintaining alphabetical order:

20 MHz-only non-AP high efficiency STA (HE STA): A non-AP HE STA that indicates in the Channel Width Set subfield in the HE PHY Capabilities Information field of the HE Capabilities element that it transmits, support for only 20 MHz channel width for the frequency band in which it is operating.

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20 MHz operating non-AP high efficiency STA (HE STA): A non-AP HE STA that is operating in 20 MHz channel width mode, such as a 20 MHz-only non-AP HE STA or an HE STA that reduced its operating channel width to 20 MHz using operating mode indication (OMI).

broadcast resource unit (RU): a resource unit within an HE MU PPDU identified by the STA-ID value 0, 2045 and by the STAID values 2045, 2047 and 0 to $n - 1$ when the AP transmits a Multiple BSSID element and n is equal to the number of BSSs advertised by the AP in the Multiple BSSID element.

DSRP_PPDU (Delayed SRP_PPDU): a PPDU that contains a Trigger frame and that has a value other than SRP_DISALLOW in the Common Info field SPATIAL_REUSE. (Delayed SRP PPDU).

downlink (DL) high efficiency (HE) multi-user (MU) physical layer protocol data unit (PPDU): a downlink OFDMA or MU-MIMO PPDU that uses HE MU PPDU format.

extended range (ER) beacon: A Beacon frame transmitted in a high efficiency (HE) extended range (ER) single user (SU) physical layer (PHY) protocol data unit (PPDU) to form a high efficiency extended range basic service set (ER BSS).

high efficiency (HE) beamformee: An HE station (STA) that receives a HE physical layer (PHY) protocol data unit (PPDU) that was transmitted using a beamforming steering matrix.

high efficiency (HE) beamformer: An HE station (STA) that transmits a HE physical layer (PHY) protocol data unit (PPDU) using a beamforming steering matrix.

high efficiency (HE) extended range (ER) single user (SU) physical layer (PHY) protocol data unit (PPDU): A Clause 28 (High Efficiency (HE) PHY specification PPDU) PPDU with the TXVECTOR parameter FORMAT equal to HE_EXT_SU.

high efficiency (HE) extended range (ER) single-user (SU) physical layer (PHY) protocol data unit (PPDU): An HE PPDU transmitted with HE ER SU PPDU format that carries one PHY service data units (PSDU) for one user.

high efficiency (HE) masked HE LTF sequence mode: A UL MU-MIMO LTF mode that uses masked HE LTF sequence of each spatial stream by a distinct orthogonal code.

high efficiency (HE) modulation and coding scheme (HE-MCS): A specification of the HE physical layer (PHY) parameters that consists of modulation order (e.g., BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM, 1024-QAM) and forward error correction (FEC) coding rate (e.g., 1/2, 2/3, 3/4, 5/6) and that is used in an HE PHY protocol data unit (PPDU).

high efficiency (HE) multi-user (MU) physical layer protocol data unit (PPDU): An HE PPDU transmitted with HE MU PPDU format that is capable of carrying one or more PHY service data units (PSDUs) for one or more users.

high efficiency (HE) physical layer protocol data unit (PPDU): A PPDU transmitted with the TXVECTOR parameter FORMAT equal to HE. There are four kinds of HE PPDUs and they are HE SU PPDU, HE MU PPDU, HE ER SU PPDU and HE TB PPDU respectively.

high efficiency (HE) single stream pilot HE LTF mode: A UL MU-MIMO LTF mode that uses single stream pilots.

high efficiency (HE) single-user (SU) physical layer protocol data unit (PPDU): An HE PPDU transmitted with HE SU PPDU format that carries one PHY service data unit (PSDU) for one user.

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high efficiency (HE) trigger-based (TB) physical layer protocol data unit (PPDU): An HE PPDU transmitted with HE TB PPDU format that is capable of carrying one or more PHY service data units (PSDU) for one or more users.

non-orthogonal frequency division multiple access (non-OFDMA) high efficiency (HE) physical layer (PHY) protocol data unit (PPDU): A 20 MHz HE PPDU with a 242-tone resource unit (RU), a 40 MHz HE PPDU with a 484-tone RU, an 80 MHz HE PPDU with a 996-tone RU, or a 160 MHz or 80+80 MHz HE PPDU with a 2×996-tone RU.

opportunistic power save (OPS) STA: A non-AP HE STA that support the opportunistic power save mechanism.

opportunistic power save (OPS) AP: An HE AP that support the opportunistic power save mechanism.

orthogonal frequency division multiple access (OFDMA): An OFDM-based multiple access scheme that different group of subcarriers are allocated to different users of the channel, allowing simultaneous data transmission to or from several users of the channel.

orthogonal frequency division multiple access (OFDMA)-based random access: A random access mechanism for HE non-AP STAs to participate in uplink OFDMA transmissions in one or more designated random access resource units (RUs).

orthogonal frequency division multiple access (OFDMA) high efficiency (HE) physical layer (PHY) protocol data unit (PPDU): A 20 MHz HE PPDU with RUs smaller than 242-tone, or a 40 MHz HE PPDU with RUs smaller than 484-tone, or an 80 MHz HE PPDU with RUs smaller than 996-tone, or a 160 MHz or 80+80 MHz HE PPDU with RUs smaller than 2×996-tone.

overlapping basic service set (OBSS) packet detect (PD): A packet detection level used for spatial reuse procedure.

overlapping basic service set (OBSS) packet detect (PD) spatial reused (SR) opportunity: A time period that starts when a STA regards an OBSS PPDU as not received at all under OBSS_PD SR conditions, and that ends at the end of the TXOP that the STA gains once its backoff reaches zero.

overlapping basic service set (OBSS) packet detect (PD) spatial reused (SR) physical layer (PHY) protocol data unit (PPDU): a PPDU that is transmitted during a spatial reuse opportunity that was determined using the OBSS_PD threshold.

resource unit (RU): a group of 26, 52, 106, 242, 484, 996 or 2×996 subcarriers as an allocation unit.

spatial reused (SR) physical layer (PHY) protocol data unit (PPDU): a PPDU that is transmitted during a spatial reuse opportunity.

SR_PPDU: a PPDU transmitted during an SRP opportunity by an HE STA when SRP conditions for SRP-based spatial reuse operation are satisfied.

SRP PPDU: a PPDU that is a DSRP_PPDU

target wake time (TWT) scheduling access point (AP): An AP that schedules broadcast TWTs and provides these schedules in a broadcast TWT element.

target wake time (TWT) scheduled STA: A STA that follows the schedules provided in a broadcast TWT element.

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uplink (UL) multi-user (MU) physical layer protocol data unit (PPDU): an uplink OFDMA or MU-MIMO PPDU that using HE TB PPDU format.

3.4 Abbreviations and acronyms

Insert the following acronym definitions (maintaining alphabetical order):

A-Control	Aggregated control
BQR	Bandwidth query report
BQRP	Bandwidth query report poll
BRP	Beamforming report poll
BSR	Buffer status report
BSRP	Buffer status report poll
CAS	Command and status
CCDF	Complementary cumulative distribution function
CQI	Channel quality indication
DCM	Dual carrier modulation
DL	Downlink
DL MU	Downlink multi-user
DL OFDMA	Downlink orthogonal frequency division multiple access
DSRP_PPDU	Delayed SRP_PPDU
HE	High efficiency
LA	Link adaptation
MU-BAR	Multi-user block ack request
MU-RTS	Multi-user request to send
MUEDCATimer	Multi-user EDCA timer
OBO	Orthogonal frequency division multiple access (OFDMA) random access backoff
OCW	Orthogonal frequency division multiple access (OFDMA) contention window
OFDMA	Orthogonal frequency division multiple access
OM	Operating mode
OMI	Operating mode indication
OMN	Operating mode notification
PPE	Physical layer (PHY) padding extension
PPET	Physical layer (PHY) padding extension threshold
QTP	Quiet time period
RDP	Reverse direction protocol
ROM	Receive operating mode
RU	Resource unit
SF	Scaling factor
SRP	Spatial reuse parameters
SR	Spatial reuse
SRG	Spatial reuse group
TB	Trigger-based
TOM	Transmit operating mode
UL	Uplink
UL MU	Uplink multi-user
UL OFDMA	Uplink orthogonal frequency division multiple access

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UMRS	Uplink multi-user response scheduling
UORA	Uplink orthogonal frequency division multiple access (OFDMA) based random access
UPH	Uplink power headroom

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4. General description

4.3 Components of the IEEE Std 802.11 architecture

Insert a new subclause after subclause 4.3.14 as follows:

4.3.14a High efficiency (HE) STA

The IEEE 802.11 HE STA operates in frequency bands between 1 GHz and 6 GHz.

An HE STA that is a mesh STA does not transmit and does not receive HE MU PPDUs or HE TB PPDUs.

In the 5 GHz band, the following apply:

- An HE STA is also a VHT STA
- An HE STA shall support operation in 20 MHz channel width
- An HE STA shall support operation in 40 MHz and 80 MHz channel width unless the STA indicates that it only supports 20 MHz channel width
- An HE STA may support operation in 160 MHz and 80+80 MHz channel bandwidth

In the 2.4 GHz band, the following apply:

- An HE STA is also an HT STA
- An HE STA shall support operation in 20 MHz channel width
- An HE STA may support operation in 40 MHz channel width

The main PHY features in an HE STA that are not present in VHT STA or HT STA are the following:

- Mandatory support for DL and UL OFDMA
- Mandatory support for DL MU-MIMO by an HE AP that supports 4 or more spatial streams when MU-MIMO is done on the entire PPDU bandwidth
- Mandatory support for DL MU-MIMO reception for an non-AP HE STA
- Optional support for the HE sounding protocol to support beamforming
- Optional support for HE-MCSs 10 and 11
- Optional support for UL MU-MIMO
- Optional support for preamble puncturing

The main MAC features in an HE STA that are not present in VHT STA or non-AP HT STA are the following:

- Optional support for dynamic fragmentation levels 1, 2 and 3
- Mandatory support for an AP to receive and optional an AP to transmit operating mode indication
- Optional support for a non-AP STA to transmit and receive for operating mode indication
- Mandatory support for a non-AP STA and optional support for an AP for two NAV operation
- Optional support in a non-AP STA and mandatory support in an AP for target wake time (TWT) operation
- Optional support for UL OFDMA-based random access (UORA)
- Optional support for spatial reuse operation
- Optional support for multi-TID A-MPDU operation
- Optional support for ER BSS
- Mandatory support in a non-AP STA for Multi-BSSID

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An HE AP sends a Trigger frame to initiate OFDMA or MU-MIMO transmissions in the uplink direction. The Trigger frame identifies non-AP STAs participating in the UL MU transmissions and assigns RUs to these STAs. Multi-STA BlockAck frames can be used by the AP to acknowledge the transmissions from the multiple non-AP STAs. Trigger frames can be scheduled by the AP to allow non-AP STAs to save power. The scheduling of these Trigger frames can be set up between a non-AP STA and the AP using TWT operation.

4.3.18 Wireless network management

4.3.18.8 Event reporting

Change 4.3.18.8 as follows:

Event requests enable a STA to request a non-AP STA to send particular real-time event reports. The types of events include transition, RSNA, WNM log, BSS Color Collision, and peer-to-peer link events. A transition event is transmitted after a non-AP STA successfully completes a BSS transition. Transition events are used to diagnose transition performance problems. An RSNA event report describes the type of Authentication used for the RSNA. RSNA events are used to diagnose security and authentication performance problems. A WNM log event report enables a non-AP STA to transmit a set of WNM log event messages to the requesting STA. WNM log event reports are used to access the contents of a STA's WNM log. A BSS color collision event report enables a non-AP HE STA to signal BSS color collision to its associated AP. A peer-to-peer link event report enables a non-AP STA to inform the requesting STA that a peer-to-peer link has been established. peer-to-peer link event reports are used to monitor the use of peer-to-peer links in the network.

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6. Layer management

6.1 Overview of management model

6.2 Generic management primitives

6.3 MLME SAP interface

6.3.3 Scan

6.3.3.3 MLME-SCAN.confirm

6.3.3.3.2 Semantics of the service primitive

Insert the following rows at the end of the BSSDescriptionSet table:

Name	Type	Valid range	Description	IBSS adoption
HE Capabilities	As defined in frame format	As defined in 9.4.2.237 (HE Capabilities element)	The value from HE Capabilities element. The parameter is present if dot11HEOptionImplemented is true and HE Capabilities element was present in the Probe Response or Beacon frame from which the BSSDescription was determined. Otherwise, the parameter is not present.	Do not adopt
HE Operation	As defined in frame format	As defined in 9.4.2.238 (HE Operation element)	The value from HE Operation element. The parameter is present if dot11HEOptionImplemented is true and an HE Operation element was present in the Probe Response or Beacon frame from which the BSSDescriptionSet was determined. Otherwise, the parameter is not present.	Adopt
UORA Parameter Set	As defined in frame format	As defined in 9.4.2.239 (UL OFDMA-based Random Access (UORA) Parameter Set element)	The UORA Parameter Set element is optionally present when dot11OFDMARandomAccessOptionImlemented is true; otherwise it is not present.	Do not adopt

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6.3.4 Synchronization

6.3.4.2 MLME-JOIN.request

6.3.4.2.2 Semantics of the service primitive

Change the primitive parameters as follows (not all existing parameters in the baseline are shown):

The primitive parameters are as follows:

MLME-JOIN.request(

...,

HE Capabilities,

VendorSpecificInfo

)

Insert the following entry into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.237 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the STA. The parameter is present if dot11HEOptionImplemented is true; otherwise, this parameter is not present.

6.3.4.2.4 Effect of receipt

Insert the following at the end of the subclause:

If the MLME of an HE STA receives an MLME-JOIN.request primitive with a SelectedBSS parameter containing a Basic HE-MCS And NSS Set field in the HE Operation parameter that contains any unsupported <HE-MCS, NSS> tuple, the MLME response in the resulting MLME-JOIN.confirm primitive shall contain a ResultCode parameter that is not set to the value SUCCESS.

6.3.7 Associate

6.3.7.4 MLME-ASSOCIATE.indication

6.3.7.4.2 Semantics of the service primitive

Change the primitive parameters as follows (not all existing parameters in the baseline are shown):

The primitive parameters are as follows:

MLME-ASSOCIATE.indication(

...,

HE Capabilities,

VendorSpecificInfo

)

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Insert the following entry into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.237 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the peer STA. The parameter is present if it is present in the Association Request frame received from the STA; otherwise, this parameter is not present.

6.3.8 Reassociate

6.3.8.4 MLME-REASSOCIATE.indication

6.3.8.4.2 Semantics of the service primitive

Change the primitive parameters as follows (not all existing parameters in the baseline are shown):

The primitive parameters are as follows:

MLME-REASSOCIATE.indication(

...,

HE Capabilities,

VendorSpecificInfo

)

Insert the following entry into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element.	As defined in 9.4.2.237 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the peer STA. The parameter is present if it is present in the Reassociation Request frame received from the STA; otherwise, this parameter is not present.

6.3.11 Start

6.3.11.2 MLME-START.request

6.3.11.2.2 Semantics of the service primitive

Change the primitive parameters as follows (not all existing parameters in the baseline are shown):

MLME-START.request(

...,

HE Capabilities,

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HE Operation,
VendorSpecificInfo
)

Insert the following entry into the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element.	As defined in 9.4.2.237 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the STA. The parameter is present if dot11HEOptionImplemented is true; otherwise, this parameter is not present.
HE Operation	As defined in HE Operation element.	As defined in 9.4.2.238 (HE Operation element)	The additional HE capabilities to be advertised for the BSS. The parameter is present if dot11HEOptionImplemented is true; otherwise, this parameter is not present.

6.3.11.2.4 Effect of receipt

Insert the following at the end of the subclause:

If the MLME of an HE STA receives an MLME-JOIN.request primitive with a SelectedBSS parameter containing a Basic HE-MCS And NSS Set field in the HE Operation parameter that contains any unsupported <HE-MCS, NSS> tuple, the MLME response in the resulting MLME-JOIN.confirm primitive shall contain a ResultCode parameter that is not set to the value SUCCESS.

6.3.27 Management of direct links

6.3.27.3 MLME-DLS.confirm

6.3.27.3.2 Semantics of the service primitive

Change the primitive parameters as follows (not all existing parameters in the baseline are shown):

MLME-DLS.confirm(

...,
HE Capabilities,
VendorSpecificInfo
)

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Insert the following entry to the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.237 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise, not present.

6.3.27.4 MLME-DLS.indication

6.3.27.4.2 Semantics of the service primitive

Change the primitive parameters as follows (not all existing parameters in the baseline are shown):

MLME-DLS.indication(

...,
HE Capabilities,
VendorSpecificInfo
)

Insert the following entry to the unnumbered table in this subclause maintaining the primitive order above:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element	As defined in 9.4.2.237 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HEOptionImplemented is true; otherwise, not present.

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8. PHY service specification

8.3 Detailed PHY service specifications

8.3.4 Basic service and options

8.3.4.4 Vector descriptions

Insert rows at the end of Table 8-4 as follows:

Table 8-4—Vector descriptions

Parameter	Associated vector	Value
CH_BANDWIDTH	TRIGVECTOR	Indicates the bandwidth in the HE-SIG-A of the HE TB PPDU. Enumerated type: CBW20 for 20 MHz CBW40 for 40 MHz CBW80 for 80 MHz CBW160 for 160 MHz CBW80+80 for 80+80 MHz
GI_HELTF TYPE	TRIGVECTOR	Indicates the GI and HE-LTF type of the coming HE TB PPDU. Enumerated type: 1x LTF + 1.6 us GI 2x LTF + 1.6 us GI 4x LTF + 3.2 us GI
MU-MIMO LTF MODE	TRIGVECTOR	Indicates the LTF mode of the UL MU-MIMO HE TB PPDU and not using 1x HE-LTF. Set to 0 to indicate that HE single stream pilot HE LTF mode is used. Set to 1 to indicate that HE masked HE LTF sequence mode is used.
NUMBER_OF_HELTF_SYMBOLS	TRIGVECTOR	Indicates the number of HE-LTF symbols present in the HE TB PPDU. Set to 0 for 1 HE-LTF symbol Set to 1 for 2 HE-LTF symbols Set to 2 for 4 HE-LTF symbols Set to 3 for 6 HE-LTF symbols Set to 4 for 8 HE-LTF symbols Other values are reserved.
STBC	TRIGVECTOR	Indicates the status of STBC encoding of the HE TB PPDU. Set to 1 if STBC encoding is used. Set to 0 otherwise.
LDPC_EXTRA_SYMBOL	TRIGVECTOR	Indicates the status of the LDPC extra symbol segment. Set to 1 if LDPC extra symbol segment is present Set to 0 otherwise.

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Table 8-4—Vector descriptions *(continued)*

Parameter	Associated vector	Value
PRE-FEC FACTOR	TRIGVECTOR	Indicates the pre-FEC padding factor. Set to 0 to indicate a pre-FEC padding factor of 4. Set to 1 to indicate a pre-FEC padding factor of 1. Set to 2 to indicate a pre-FEC padding factor of 2. Set to 3 to indicate a pre-FEC padding factor of 3.
PE DISAMBIGUITY	TRIGVECTOR	Indicates PE disambiguity. Set to 0 to indicate no PE disambiguity. Set to 1 to indicate PE disambiguity.
SPATIAL_REUSE	TRIGVECTOR	Indicates the value for the Spatial Reuse field in the HE-SIG-A field of the coming HE TB PPDU NOTE—For 20 MHz one SR field corresponding to entire 20 MHz (other 3 fields indicate identical values). For 40 MHz two SR fields for each 20 MHz (other 2 fields indicate identical values). For 80 MHz four SR fields for each 20 MHz. For 160 MHz four SR fields for each 40 MHz.
DOPPLER	TRIGVECTOR	Indicates a high Doppler mode of transmission. Set to 0 to indicate a high Doppler mode of transmission. Set to 1 otherwise.
AID12 LIST	TRIGVECTOR	Carries the 12 LSBs of the AID of each triggered STA. NOTE—Each element of AIDLIST is (12-bit) AID of the corresponding HE TB PPDU. See the AID12 subfield in 9.3.1.23 (Trigger frame format) for more information of each element.
RU_ALLOCATION_LIST	TRIGVECTOR	8 bits are used per STA to indicate the RU allocated in the whole bandwidth with the same encoding scheme as in Table 9-25h (The encoding of B19–B13 of the RU Allocation subfield). See 9.3.1.23 (Trigger frame format).
CODINGTYPE_LIST	TRIGVECTOR	Carries the code type of each triggered STA in coming HE_TB PPDU. NOTE—Each element of CODINGTYPE_LIST indicates coding type of the corresponding HE TB PPDU. Please see Coding Type subfield in 9.3.1.23 (Trigger frame format) for more information of each element.

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Table 8-4—Vector descriptions *(continued)*

Parameter	Associated vector	Value
MCS_LIST	TRIGVECTOR	Carries the MCS of each triggered STA in coming HE_TB PPDU. NOTE—Each element of MCS_LIST indicates MCS of the corresponding HE TB PPDU. Please see Coding Type subfield in 9.3.1.23 (Trigger frame format) for more information of each element.
SS_ALLOCATION_LIST	TRIGVECTOR	Indicates spatial streams of each triggered STA in coming HE_TB PPDU. NOTE—Each element of SS_ALLOCATION_LIST indicates spatial streams of the corresponding HE TB PPDU.Please see SS Allocation subfield in 9.3.1.23 (Trigger frame format) for more information of each element.

Insert as the last paragraph of 8.3.4.4:

The Clause 28 PHY TXVECTOR and RXVECTOR contain additional parameters related to the operation of the Clause 28 PHY modes of operation as described in 28.2 (HE PHY service interface). In certain modes of operation, the DATARATE parameter is replaced by MCS, CH_BANDWIDTH, RU_ALLOCATION, NUM_STS, STBC, GI_TYPE and DCM values. The mapping from these values to data rate is defined in 28.5 (Parameters for HE-MCSs), where HE-MCS is MCS and NSS is NUM_STS / (STBC + 1).

8.3.5 PHY SAP detailed service specification

8.3.5.2 PHY-DATA.request

8.3.5.2.2 Semantics of the service primitive

Change the subclause as follows:

The primitive provides the following parameter:

PHY-DATA.request(
DATA,
USER_INDEX,
STA_INDEX
)

The DATA parameter is an octet of value X'00' to X'FF'.

The USER_INDEX parameter (typically identified as *u* for a VHT STA; see NOTE 1 at the end of Table 21-1 (TXVECTOR and RXVECTOR parameters)) is present for a VHT MU PPDU and indicates the index of the user in the TXVECTOR to which the accompanying DATA octet applies; otherwise, this parameter is not present.

The STA_INDEX parameter (identified as an element of the STA_ID_LIST parameter; see STA_ID_LIST parameter in Table 28-1 (TXVECTOR and RXVECTOR parameters) and 27.11.1 (STA_ID_LIST)) is present for an HE MU PPDU and indicates the STA or group of STAs that is the recipient of an RU to which the accompanying DATA octet applies; otherwise, this parameter is not present.

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8.3.5.3 PHY-DATA.indication

8.3.5.3.2 Semantics of the service primitive

Change the subclause as follows:

The primitive provides the following parameter:

PHY-DATA.indication(
DATA,
STA_INDEX
)

The DATA parameter is an octet of value X'00' to X'FF'.

The STA_INDEX parameter is present for an HE TB PPDU and indicates the index of the user in the RXVECTOR to which the accompanying DATA octet applies; otherwise, this parameter is not present.

The STA_INDEX parameter (identified as an AID of the transmitter of the DATA contained in an HE TB PPDU; see STA_ID_LIST parameter in Table 28-1 (TXVECTOR and RXVECTOR parameters)) is present for an HE TB PPDU and indicates the STA of an RU from which the accompanying DATA octet applies; otherwise, this parameter is not present.

8.3.5.10 PHY-CCARESET.request

8.3.5.10.3 When generated

Insert the following after the 1st paragraph:

This primitive is also generated by the MAC sublayer for the local PHY entity when the spatial reuse conditions defined in 27.9 (Spatial reuse operation) are met.

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8.3.5.12 PHY-CCA.indication

8.3.5.12.2 Semantics of the service primitive

Change Table 8-5 (The channel-list parameter elements) as follows:

Table 8-5—The channel-list parameter elements

channel-list element	Meaning
primary	In an HT STA ~~that is not a VHT STA~~, indicates that the primary 20 MHz channel is busy. In a VHT STA, indicates that the primary 20 MHz channel is busy according to the rules specified in 21.3.18.5.3 (CCA sensitivity for signals occupying the primary 20 MHz channel). In a TVHT STA, indicates that the primary channel is busy according to the rules specified in 22.3.18.6.3 (CCA sensitivity for signals occupying the primary channel). In an HE STA, indicates that the primary 20 MHz channel is busy according to the rules specified in 28.3.19.6.3 (CCA sensitivity for the primary 20 MHz channel).
secondary	In an HT STA ~~that is not a VHT STA~~, indicates that the secondary channel is busy. In a VHT STA, indicates that the secondary 20 MHz channel is busy according to the rules specified in 21.3.18.5.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel). In a TVHT STA, indicates that the secondary channel is busy according to the rules specified in 22.3.18.6.4 (CCA sensitivity for signals not occupying the primary channel). In an HE STA, indicates that the secondary 20 MHz channel is busy according to the rules specified in 28.3.19.6.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel).
secondary40	In a VHT STA, indicates ~~Indicates~~ that the secondary 40 MHz channel is busy according to the rules specified in 21.3.18.5.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel). In a TVHT STA, indicates that the secondary TVHT_2W channel is busy according to the rules specified in 22.3.18.6.4 (CCA sensitivity for signals not occupying the primary channel). In an HE STA, indicates that the secondary 40 MHz channel is busy according to the rules specified in 28.3.19.6.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel).
secondary80	In a VHT STA, indicates ~~Indicates~~ that the secondary 80 MHz channel is busy according to the rules specified in 21.3.18.5.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel). In an HE STA, indicates that the secondary 80 MHz channel is busy according to the rules specified in 28.3.19.6.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel).
per20MHzbitmap	In an HE STA, indicates the busy/idle status of each 20 MHz subchannel in 80 MHz, 160 MHz or 80+80 MHz according to the rules specified in 28.3.19.6.5 (Per 20 MHz CCA sensitivity). Valid only for the 20 MHz subchannels that require CCA operation for the preamble puncturing transmission, HE TB PPDU transmission and BQR operation.
NOTE—The term HT STA has been overloaded to refer to an HT STA that is neither a VHT STA nor an HE STA and the term VHT STA has been overloaded to refer to a VHT STA that is not an HE STA.	

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8.3.5.12.3 When generated

Change the first paragraph and remove the note as follows:

For Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) to Clause 20 (Directional multi-gigabit (DMG) PHY specification) PHYs, this primitive is generated within aCCATime of the occurrence of a change in the status of the primary channel from channel idle to channel busy or from channel busy to channel idle or when the elements of the channel-list parameter change. For Clause 21~~ and,~~ Clause 22 and Clause 28 PHYs, this primitive is generated when the status of the channel(s) changes from channel idle to channel busy or from channel busy to channel idle or when the elements of the channel-list parameter change. This includes the period of time when the PHY is receiving data. The timing of PHY-CCA.indication primitives related to transitions on secondary channel(s) is PHY specific. Refer to specific PHY clauses for details about CCA behavior for a given PHY.

~~NOTE—For the VHT PHY, the timing information is omitted here and is defined in 21.3.18.5.~~

8.3.5.18 PHY-TRIGGER.request

8.3.5.18.1 Function

This primitive is a request by the MAC sublayer to the local PHY entity to provide parameters for the receipt of HE TB PPDU.

8.3.5.18.2 Semantics of the service primitive

The primitive provides the following parameter:

```
PHY-TRIGGER.request (
                        TRIGVECTOR
                        )
```

The TRIGVECTOR represents a list of parameters (contains common info and all user info of trigger frame) that the MAC sublayer provides to the local PHY entity in order to receive the HE TB PPDUs.

8.3.5.18.3 When generated

This primitive is issued by the MAC sublayer to the PHY entity after issuing PHY-TXSTART.request and before receiving HE TB PPDU.

8.3.5.18.4 Effect of receipt

The effect of receipt of this primitive by the PHY entity is to configure receiver module with parameters in TRIGVECTOR before HE TB PPDUs arrival.

8.3.5.19 PHY-TRIGGER.confirm

8.3.5.19.1 Function

This primitive is issued by the PHY to the local MAC entity to confirm that the PHY has applied the parameters provided in the PHY-TRIGGER.request primitive.

8.3.5.19.2 Semantics of the service primitive

The semantics of the primitive are as follows:

```
PHY-TRIGGER.confirm ()
```

This primitive has no parameters.

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8.3.5.19.3 When generated

This primitive is issued by the PHY to the MAC entity when the PHY has received and successfully applied the parameters in the PHY-TRIGGER.request primitive.

8.3.5.19.4 Effect of receipt

The effect of the receipt of this primitive by the MAC is unspecified.

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9. Frame formats

9.2 MAC frame formats

9.2.4 Frame fields

9.2.4.1 Frame Control field

9.2.4.1.3 Type and Subtype subfields

Change the row below and insert a new row immediately after it in Table 9-1 (Valid type and subtype combinations) as follows:

Table 9-1—Valid type and subtype combinations

Type value B3 B2	Type description	Subtype value B7 B6 B5 B4	Subtype description
01	Control	0000 ~~0010~~0001	Reserved
01	Control	0010	Trigger

9.2.4.1.8 More Data subfield

Change the 4th and 5th paragraphs as follows:

An AP optionally sets the More Data subfield to 1 in Ack frames sent to a non-DMG non-HE STA and in Ack, BlockAck and Multi-STA BlockAck frames sent to an HE STA. An HE AP indicates that it supports setting the More Data subfield to 1 in these control response frames by setting the More Data Ack subfield to 1 in the QoS Info field of elements it includes in frames transmitted to the STA. The QoS Info field is present in the QoS Capability, EDCA Parameter Set, and MU EDCA Parameter Set elements transmitted by an HE AP.

The AP can set the More Data subfield to 1 to indicate that it has a pending transmission for the STA if it ~~from which it~~ has received a frame that contains a QoS Capability element in which the More Data Ack subfield is equal to 1 from the STA and ~~that has one or more ACs that are delivery enabled and that is in PS mode to indicate that the AP has a pending transmission for the STA~~ one of the following conditions is true:

- The STA is in PS mode and has one or more ACs that are delivery enabled (see 11.2.2.6 (AP operation during the CP)).
- The STA is in PS mode and is a TWT requester or a TWT scheduled STA (see 27.7 (TWT operation))

A TDLS peer STA optionally sets the More Data subfield to 1 in Ack frames sent to a non-HE STA and in Ack, BlockAck, and Multi-STA BlockAck frames sent to an HE STA. An HE TDLS peer STA indicates that it supports setting the More Data subfield to 1 in these control response frames by setting the More Data Ack subfield to 1 in the QoS Info field of the QoS Capability element it includes in frames transmitted to the STA.

The TDLS peer STA can set the More Data subfield to 1 to indicate that it has pending transmission for the STA if it has received from the STA a TDLS Setup Request frame or TDLS Setup Response frame ~~that has TDLS peer PSM enabled and~~ that has the More Data Ack subfield equal to 1 in the QoS Capability element

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~~of its transmitted TDLS Setup Request frame or TDLS Setup Response frame to indicate that it has a pending transmission for the STA.~~ and one of the following conditions is true:

- The STA has TDLS peer PSM enabled (see 11.2.2.6 (AP operation during the CP))
- The STA is in PS mode and is a TWT requester or a TWT scheduled STA (see 27.7 (TWT operation)).

9.2.4.1.10 +HTC/Order subfield

Change this subclause as follows:

The +HTC/Order subfield is 1 bit in length. It is used for two purposes:

- It is set to 1 in a non-QoS Data frame transmitted by a non-QoS STA to indicate that the frame contains an MSDU, or fragment thereof, that is being transferred using the StrictlyOrdered service class.
- It is set to 1 in a QoS Data, QoS Null or Management frame transmitted with a value of HT_GF, HT_MF, VHT, HE or S1G for the FORMAT parameter of the TXVECTOR to indicate that the frame contains an HT Control field.
- It is set to 1 in an S1G RTS frame to indicate that the intended recipient of the frame has permission to extend the TXOP as described in 10.51.5.4 (Relay-shared TXOP protection mechanisms).

Otherwise, the +HTC/Order field is set to 0.

NOTE—The +HTC/Order field is always set to 0 for frames transmitted by a DMG STA.

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9.2.4.5 QoS Control field

9.2.4.5.4 Ack Policy subfield

Change Table 9-9 (Ack Policy subfield in QoS Control field of QoS Data frames) as follows (only relevant row shown):

Table 9-9—Ack Policy subfield in QoS Control field of QoS Data frames

Bits in QoS Control field		Meaning
Bit 5	Bit 6	
0	1	No explicit acknowledgment, ~~or~~ PSMP Ack or HE TB PPDU (HTP) Ack. When the frame is not carried in a DL HE MU PPDU or HE SU PPDU that solicits an HE TB PPDU: When bit 6 of the Frame Control field (see 9.2.4.1.3 (Type and Subtype subfields)) is set to 1: There might be a response frame to the frame that is received, but it is neither the Ack frame nor any Data frame of subtype +CF-Ack. The Ack Policy subfield for QoS CF-Poll and QoS CF-Ack +CF-Poll Data frames is set to this value. When bit 6 of the Frame Control field (see 9.2.4.1.3 (Type and Subtype subfields)) is set to 0: The acknowledgment for a frame indicating PSMP Ack when it appears in a PSMP downlink transmission time (PSMP-DTT) is to be received in a later PSMP uplink transmission time (PSMP-UTT). The acknowledgment for a frame indicating PSMP Ack when it appears in a PSMP-UTT is to be received in a later PSMP-DTT. When the frame is carried in a DL HE MU PPDU that solicits an HE TB PPDU the addressed recipient returns an Ack, BlockAck, or Multi-STA BlockAck frame carried in an HE TB PPDU a SIFS after the DL HE MU PPDU as defined in 10.3.2.10.2 (Acknowledgement procedure for DL MU PPDU in MU format) and 27.5.3 (UL MU operation). NOTE—Bit 6 of the Frame Control field (see 9.2.4.1.3 (Type and Subtype subfields)) indicates the absence of a data Frame Body field. When equal to 1, the QoS Data frame contains no Frame Body field, and any response is generated in response to a QoS CF-Poll or QoS CF-Ack +CF-Poll frame, but does not signify an acknowledgment of data. When set to 0, the QoS Data frame contains a Frame Body field, which is acknowledged as described in 10.29.2.7 (PSMP acknowledgment rules).

9.2.4.5.6 Queue Size subfield

Change subclause 9.2.4.5.6 as follows:

The Queue Size subfield is an 8-bit field that indicates the amount of buffered traffic for a given TC or TS at the non-HE STA sending ~~this frame~~ the frame that contains this subfield. A non-AP HE STA uses the Queue Size subfield to indicate the amount of buffered traffic intended for transmission to the HE STA identified by the receive address of the frame containing the QoS Control field. The Queue Size subfield is present in QoS Data and QoS Null frames sent by non-AP STAs with bit 4 of the QoS Control field equal to 1. The AP might use information contained in the Queue Size subfield to determine the TXOP duration assigned to the STA or to determine the UL resources assigned to the HE STA (see 27.5.3 (UL MU operation)).

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When sent by a non-HE STA or transmitted to a non-HE STA, the queue size value is the approximate total size, rounded up to the nearest multiple of 256 octets and expressed in units of 256 octets, of all MSDUs and A-MSDUs buffered at the STA (excluding the MSDU or A-MSDU of the present QoS Data frame) in the delivery queue used for MSDUs and A-MSDUs with TID values equal to the value in the TID subfield of this QoS Control field.

When sent by a non-AP HE STA to an HE AP the Queue Size subfield contains a Scaling Factor subfield in the 2 MSBs (bits 14-15) of the QoS Control subfield and an unscaled value, *UV*, in the 6 LSBs (bits 8-13) of the QoS Control subfield. The Scaling Factor subfield provides the scaling factor, *SF*, with an encoding that is shown in Figure 9-18d (Scaling Factor subfield encoding). The queue size value, *QS*, for a non-AP HE STA transmitting the Queue Size subfield to an HE AP is calculated as follows:

$$QS = \begin{cases} 16 \times UV, \text{ if the Scaling Factor subfield is 0} \\ 1024 + 256 \times UV, \text{ if the Scaling Factor subfield is 1} \\ 17\,408 + 2048 \times UV, \text{ if the Scaling Factor subfield is 2} \\ 148\,480 + 32\,768 \times UV, \text{ if the Scaling Factor subfield is 3} \end{cases} \quad \text{(9-ax1)}$$

When transmitted by a non-AP HE STA to an HE AP, the ~~The~~ queue size value, *QS*, is the approximate total size, ~~rounded up to the nearest multiple of 256~~ in octets, of all MSDUs and A-MSDUs buffered at the STA (~~excluding the MSDU or A-MSDU of the present QoS Data frame~~ including the MSDUs or A-MSDUs contained in the (A-)MPDU containing the Queue Size subfield) in the delivery queue used for MSDUs and A-MSDUs with TID values equal to the value in the TID subfield of this QoS Control field. *QS* is calculated as defined in Equation (9-ax1). *QS* is an approximation of the actual queue size at the transmitter, where the approximation is due to rounding to a variable resolution. The transmitter rounds the actual value of queue size up to the nearest 16 octets when *SF* is equal to 0 and places the resulting value into the UV subfield. The transmitter rounds the actual queue size as follows, for *SF* values greater than 0:

— When *SF* is equal to 1, the actual queue size minus 1024 is rounded up to the nearest 256 octets and placed into the UV subfield.

— When *SF* is equal to 2, the actual queue size minus 17,408 is rounded up to the nearest 2048 octets and placed into the UV subfield.

— When *SF* is equal to 3, the actual queue size minus 148,480 is rounded up to the nearest 32,768 octets and placed into the UV subfield.

A queue size value of 0 is used ~~solely~~ to indicate the absence of any buffered traffic in the queue used for the specified TID. A queue size value of 254 is used for all sizes greater than 64 768 octets when transmitted by a non-HE STA or transmitted by an HE STA to a non-HE STA and 2 147 328 octets when transmitted by an HE STA to an HE STA. A queue size value of 255 is used to indicate an unspecified or unknown size. If an MSDU or A-MSDU is fragmented and is not carried in an A-MPDU, then the queue size value may remain constant in all fragments even if the amount of queued traffic changes as successive fragments are sent. If an MSDU or A-MSDU is fragmented and is carried in an A-MPDU, then the queue size bits 8-15 of the QoS Control field is set as defined in 10.13.1 (A-MPDU contents).

9.2.4.6 HT Control field

9.2.4.6.1 General

Remove Figure 9-8 (HT Control field).

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Insert Table 9-9a as follows:

Table 9-9a—HT Control field

Variant	Bit 0 (value)	Bit 1 (value)	Bit 2-29	Bit 30	Bit 31
HT variant	VHT (0)	HT Control Middle		AC Constraint	RDG/More PPDU
VHT variant	VHT (1)	HE (0)	VHT Control Middle	AC Constraint	RDG/More PPDU
HE variant	VHT (1)	HE (1)	Aggregated Control		

Change the paragraphs below of 9.2.4.6.1 as follows:

The HT Control field has ~~two~~ three forms~~,~~: the HT variant, ~~and~~ the VHT variant, and the HE variant. These forms differ in the values of the VHT and HE subfields and in their formats, which are shown in Table 9-9a (HT Control field). ~~The two forms differ in the format of the HT Control Middle subfield, described in 9.2.4.6.2 (HT variant) for the HT variant and in 9.2.4.6.3 (VHT variant) for the VHT variant and in the value of the VHT subfield.~~

The VHT subfield together with the HE subfield, if present, indicate the variant of the HT Control field. The VHT subfield is set to 0 to indicate an HT variant HT Control field. The VHT subfield is set to 1 and the HE subfield is set to 0 to indicate a VHT variant HT Control field. The VHT subfield is set to 1 and the HE subfield is set to 1 to indicate an HE variant HT Control field.

The HT Control Middle subfield is defined in 9.2.4.6.2 (HT variant) and the VHT Control Middle subfield is defined in 9.2.4.6.3 (VHT variant).

The Aggregated Control subfield is defined in 9.2.4.6.4 (A-Control).

~~The VHT subfield of the HT Control field indicates whether the HT Control Middle subfield is the VHT Variant or the HT Variant. The VHT subfield is set to 1 to indicate that the HT Control Middle subfield is the VHT Variant and is set to 0 to indicate that the HT Control Middle subfield is the HT Variant.~~

9.2.4.6.3 VHT variant

Change the paragraph below as follows:

The format of the VHT Control Middle subfield of the VHT variant HT Control field is shown in Figure 9-13 (VHT Control Middle subfield of the VHT variant HT Control field).

Change Figure 9-13 as follows (remove Reserved field and change title):

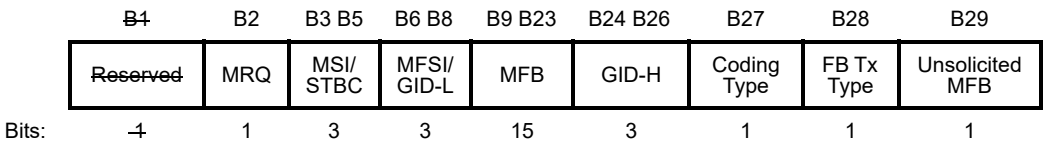


Figure 9-13—VHT Control Middle subfield of the VHT variant HT Control field

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Insert a new subclause 9.2.4.6.4 following 9.2.4.6.3:

9.2.4.6.4 A-Control

9.2.4.6.4.1 General

The format of the A-Control subfield of the HE variant HT Control field is shown in Figure 9-15a (A-Control subfield of the HE variant HT Control field).

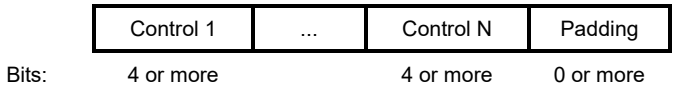


Figure 9-15a—A-Control subfield of the HE variant HT Control field

The A-Control subfield contains a sequence of one or more Control subfields. The length of the A-Control subfield is equal to 30 bits. The format of each Control subfield is shown in Figure 9-15b (Control subfield format).

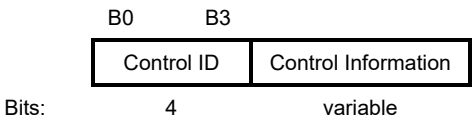


Figure 9-15b—Control subfield format

The Control ID subfield indicates the type of information carried in the Control Information subfield. The length of the Control Information subfield is fixed for each value of the Control ID subfield that is not

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reserved. The values of the Control ID subfield and the associated length of the Control Information subfield are defined in Table 9-18a (Control ID subfield values).

Table 9-18a—Control ID subfield values

Control ID value	Meaning	Length of the Control Information subfield (bits)	Content of the Control Information subfield
0	UL MU response scheduling (UMRS)	26	See 9.2.4.6.4.2 (UMRS Control)
1	Operating mode (OM)	12	See 9.2.4.6.4.3 (OM Control)
2	HE link adaptation (HLA)	26	See 9.2.4.6.4.4 (HLA Control)
3	Buffer status report (BSR)	26	See 9.2.4.6.4.5 (BSR Control)
4	UL power headroom (UPH)	8	See 9.2.4.6.4.6 (UPH Control)
5	Bandwidth query report (BQR)	10	See 9.2.4.6.4.7 (BQR Control)
6	Command Control Indication	8	See 9.2.4.6.4.8 (CAS Control))
7-15	Reserved		

The Padding subfield, if present, follows the last Control subfield and is set to a sequence of zeros so that the length of the A-Control subfield carried in the HT Control field is 30 bits.

9.2.4.6.4.2 UMRS Control

If the Control ID subfield is 0, the Control Information subfield contains UL MU response scheduling (UMRS) information for an HE TB PPDU that follows the HE MU PPDU containing this Control Information subfield (see 27.5.3.2 (Rules for soliciting UL MU frames)). The format of the subfield is shown in Figure 9-15c (Control Information subfield format when Control ID subfield is 0).

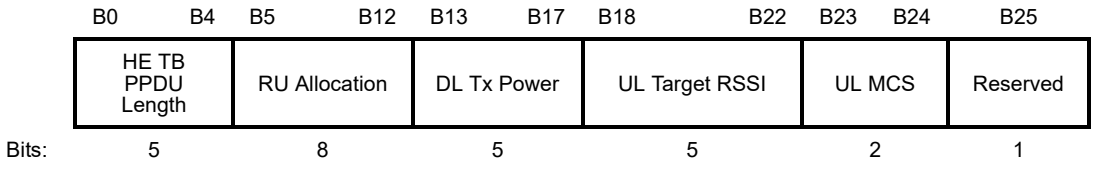


Figure 9-15c—Control Information subfield format when Control ID subfield is 0

NOTE—The A-MPDU contained in the HE TB PPDU carries one immediate acknowledgment, if the preceding PPDU solicits an acknowledgment, and it might additionally contain other frames that do not solicit immediate responses, such as QoS Null frames with Ack Policy of No Ack, Action No Ack frames, as defined in 27.5.3.3 (STA behavior for UL MU operation).

The HE TB PPDU Length subfield indicates the length of the HE TB PPDU response and is set to the number of OFDM symbols in the Data field of the HE TB PPDU minus 1. The duration of the HE TB PPDU is calculated as defined in 28.4.3 (TXTIME and PSDU_LENGTH calculation).

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The RU Allocation subfield indicates the resource unit (RU) assigned for transmitting the HE TB PPDU response and is defined in 9.3.1.23 (Trigger frame format).

NOTE—The use of BCC encoding is required if the RU Allocation subfield indicates an RU that is less than 484-tone RU. The use of LDPC encoding is required if the RU is greater than or equal to 484-tone RU (see 27.5.3.3 (STA behavior for UL MU operation)).

The DL TX Power subfield indicates the AP transmit power, in dBm, referenced to the antenna connector, combined over all TX antennas and normalized to 20 MHz bandwidth, used for the HE MU PPDU that solicits the HE TB PPDU. The transmit power, P_{TX}, is calculated as $P_{TX} = -20 + 2 \times F_{Val}$, where F_{Val} is the value of the DL TX Power subfield, except for the value 31, which is reserved.

The UL Target RSSI subfield indicates, in units of dBm, the AP target receive power (i.e., averaged RSSI over all the AP's antennas) for the responding STA when transmitting the HE TB PPDU. The target receive power is calculated as $Target_{RSSI} = -90 + 2 \times F_{Val}$, where F_{Val} is the value of the UL Target RSSI subfield, except that the value 31 indicates to the STA to transmit at maximum power for the assigned MCS.

NOTE—It is possible that a STA is unable to satisfy the target RSSI due to its hardware or regulatory limitation (see 28.3.14.2 (Power pre-correction)).

The UL MCS subfield indicates the MCS, from MCS0 to MCS3, to be used by the receiving STA for the HE TB PPDU. The UL MCS subfield is set to 0 for indicating HE-MCS 0, to 1 for HE-MCS 1, to 2 for HE-MCS 2, and to 3 for HE-MCS 3 (see 28.5 (Parameters for HE-MCSs)).

9.2.4.6.4.3 OM Control

If the Control ID subfield is 1, the Control Information subfield contains information related to the operating mode (OM) change of the STA transmitting the frame containing this information (see 27.8 (Operating mode indication)). The format of the subfield is shown in Figure 9-15d (Control Information subfield format when Control ID subfield is 1).

	B0 B2	B3 B4	B5	B6 B8	B9 B11
	Rx NSS	Channel Width	UL MU Disable	Tx NSTS	Reserved
Bits:	3	2	1	3	3

Figure 9-15d—Control Information subfield format when Control ID subfield is 1

The Rx NSS subfield indicates the maximum number of spatial streams, N_{SS}, that the STA supports in reception and is set to $N_{SS} - 1$.

The Channel Width subfield indicates the operating channel width supported by the STA for both reception and transmission. It is set to 0 for primary 20 MHz, 1 for primary 40 MHz, 2 for primary 80 MHz, and 3 for 160 MHz and 80+80 MHz.

The Rx NSS support for a given HE-MCS as a function of the received HE PPDU bandwidth *BW* at an HE STA transmitting an OM Control subfield is defined as

$$\text{floor}\,(\textit{Rx-NSS-from-OMI} \times (\textit{Max-HE-NSS-at-BW} \,/\, \textit{Max-HE-NSS-at-80})) \quad \text{(9-ax2)}$$

where

Rx-NSS-from-OMI is Rx NSS from the OM Control subfield transmitted by the STA

Max-HE-NSS-at-BW is the maximum HE NSS among all HE-MCS at *BW* MHz from the Supported HE-MCS and NSS Set field transmitted by the STA

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Max-HE-NSS-at-80 is the maximum HE NSS among all HE-MCS at 80 MHz from the Supported HE-MCS and NSS Set field transmitted by the STA

NOTE—The Rx NSS subfield indicates the maximum number of spatial streams at bandwidths that are same as or narrower than 80 MHz.

The VHT channel width and the VHT NSS allowed at an HE STA transmitting an OM Control subfield are defined in Table 9-18b (Setting of the VHT Channel Width and VHT NSS at a HE STA transmitting the OM Control subfield).

Table 9-18b—Setting of the VHT Channel Width and VHT NSS at a HE STA transmitting the OM Control subfield

OM Control subfield	VHT capabilities of STA transmitting OM Control subfield		VHT NSS Support of STA transmitting the OM Control subfield as a function of the PPDU bandwidth (× Max VHT NSS) (see requirements R1 and R2)					Location of 160 MHz center frequency if BSS bandwidth is 160 MH	Location of secondary 80 MHz center frequency if BSS bandwidth is 80+80 MHz
Channel Width	Supported Channel Width	Extended NSS BW Support	20 MHz	40 MHz	80 MHz	160 MHz	80+80 MHz		
0	0-2	0-3	1						
1	0-2	0-3	1	1					
2	0-2	0-3	1	1	1				
3	0	1	1	1	1	1/2		CCFS2	
3	0	2	1	1	1	1/2	1/2	CCFS2	CCFS2
3	0	3	1	1	1	3/4	3/4	CCFS2	CCFS2
3	1	0	1	1	1	1		CCFS1	
3	1	1	1	1	1	1	1/2	CCFS1	CCFS2
3	1	2	1	1	1	1	3/4	CCFS1	CCFS2
3	1	3	2	2	2	2	1	CCFS1	CCFS1
3	2	0	1	1	1	1	1	CCFS1	CCFS1
3	2	3	2	2	2	1	1	CCFS1	CCFS1

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Table 9-18b—Setting of the VHT Channel Width and VHT NSS at a HE STA transmitting the OM Control subfield *(continued)*

OM Control subfield	VHT capabilities of STA transmitting OM Control subfield		VHT NSS Support of STA transmitting the OM Control subfield as a function of the PPDU bandwidth (× Max VHT NSS) (see requirements R1 and R2)					Location of 160 MHz center frequency if BSS bandwidth is 160 MH	Location of secondary 80 MHz center frequency if BSS bandwidth is 80+80 MHz
Channel Width	Supported Channel Width	Extended NSS BW Support	20 MHz	40 MHz	80 MHz	160 MHz	80+80 MHz		

R1: NSS support shall be rounded down to the nearest integer.
R2: The maximum NSS support shall be 8.

NOTE 1—Max VHT NSS as indicated by the value of the Rx NSS field. The Rx NSS field indicates the same Max HE NSS and Max VHT NSS. Max VHT NSS is at the BW indicated by VHT Capabilities element, for all allowed MCS values the Max VHT NSS values are same, but the supported NSS can be different.

NOTE 2—1/2 × or 3/4 × Max VHT NSS support might end up being 0, indicating no support.

NOTE 3—Any other combination than the ones listed in this table is reserved.

NOTE 4—CCFS1 refers to the value of the Channel Center Frequency Segment 1 field of the most recently transmitted VHT Operation element.

NOTE 5—CCFS2 refers to the value of the Channel Center Frequency Segment 2 field of the most recently transmitted HT Operation element.

NOTE 6—CCFS1 is nonzero when the current BSS bandwidth is 160 MHz or 80+80 MHz and the NSS support is at least Max VHT NSS. CCFS2 is zero in this case.

NOTE 7—CCFS2 is nonzero when the current BSS bandwidth is 160 MHz or 80+80 MHz and the NSS support is less than Max VHT NSS. CCFS1 is zero in this case.

NOTE 8—At most one of CCFS1 and CCFS2 is nonzero.

NOTE 9—A supported multiple of Max VHT NSS applies to both transmit and receive. A supported multiple of Max HE NSS applies to receive

NOTE 10—Some combinations of Supported Channel Width Set and Extended NSS BW support might not occur in practice.

The UL MU Disable subfield indicates whether UL MU operation is suspended or resumed by a non-AP STA. The UL MU Disable subfield is set to 1 to indicate that UL MU operation is suspended; otherwise it is set to 0 to indicate that UL MU operation is resumed. An AP sets the UL MU Disable subfield to 0.

The Tx NSTS subfield indicates the maximum number of space-time streams, N_{STS}, that the STA supports in transmission and is set to $N_{STS} - 1$.

9.2.4.6.4.4 HLA Control

If the Control ID subfield is 2, the Control Information subfield contains information related to the HE link adaptation (HLA) procedure (see 27.13 (Link adaptation using the HLA Control field)). The format of the subfield is shown in Figure 9-15e (Control Information subfield format when Control ID subfield is 2).

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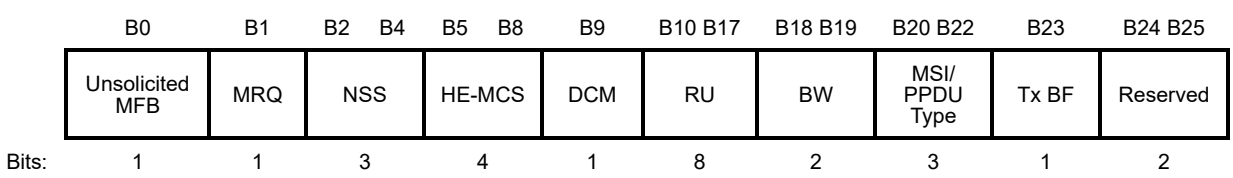


Figure 9-15e—Control Information subfield format when Control ID subfield is 2

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The HLA Control subfields are defined in Table 9-18c (HLA Control subfields).

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Table 9-18c—HLA Control subfields

Subfield	Meaning	Definition
Uosolicited MFB	Unsolicited MFB indicator	Set to 1 if the HLA Control is an unsolicited MFB. Set to 0 if the HLA Control is an MRQ or a solicited MFB.
MRQ	HLA feedback request indicator	Set to 1 and set Unsolicited MFB subfield to 0 to request an HLA feedback. Set to 0 and set Unsolicited MFB subfield to 0 to respond an HLA request. If the Unsolicited MFB subfield is 1, the MRQ subfield is reserved.
NSS	Recommended number of spatial stream	If the Unsolicited MFB subfield is 1 or if the Unsolicited MFB subfield is 0 and the MRQ subfield is 0, NSS subfield indicates the recommended number of spatial streams, NSS, and is set to NSS - 1. Otherwise, this subfield is reserved.
HE-MCS	Recommended HE-MCS	If the Unsolicited MFB subfield is 1 or if the Unsolicited MFB subfield is 0 and the MRQ subfield is 0, the HE-MCS subfield indicates the recommended HE-MCS, and is set to the HE-MCS Index value (defined in 28.5 (Parameters for HE-MCSs)). The HE-MCS subfield of the MFB subfield of HLA Control field should be set to the highest datarate, for given transmission properties, that results in frame error rate of 10% or lower for an MPDU length of 3895 octets. Otherwise, this subfield is reserved.
DCM	Recommended usage of DCM	If the Unsolicited MFB subfield is 1 or if the Unsolicited MFB subfield is 0 and the MRQ subfield is 0, the DCM subfield indicates the recommended usage of DCM. This subfield is set to 1 if DCM is recommended and is set to 0 otherwise. Otherwise, this subfield is reserved.
RU	RU index of the recommended HE-MCS/RU index specified by MFB requester to get feedback	If the Unsolicited MFB subfield is 1, the RU subfield indicates the RU index for which the recommended HE-MCS is intended, as defined in 27.13: If the Unsolicited MFB subfield is 0 and the MRQ subfiled is 1, the RU subfield indicates the RU index requested by the MFB requester to get feedback. RU index is interpreted with the BW subfield to specify the RU. RU index encoding is as defined 9.3.1.23. Otherwise, this subfield is reserved.

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Table 9-18c—HLA Control subfields *(continued)*

Subfield	Meaning	Definition
BW	Bandwidth of the recommended HE-MCS/ Bandwidth specified by MFB requester to get feedback	If the Unsolicited MFB subfield is 1, the BW subfield indicates the bandwidth for which the recommended HE-MCS is intended, as defined in 27.13. If the Unsolicited MFB subfield is 0 and the MRQ subfiled is 1, the BW subfield indicates the bandwidth requested by the MFB requester to get feedback. For an HE STA: Set to 0 for 20 MHz Set to 1 for 40 MHz Set to 2 for 80 MHz Set to 3 for 160 MHz or 80+80 MHz. Otherwise, this subfield is reserved.
MSI/PPDU Type	Packet format of the measured PPDU/ MRQ sequence identifier	If the Unsolicited MFB subfield is 0 and the MRQ subfield is 1, the MSI/PPDU-Type subfield contains a sequence number in the range 0 to 6 that identifies the specific MCS feedback request. If the Unsolicited MFB subfield is 0 and the MRQ subfield is 0, the MSI/PPDU-Type subfield contains a sequence number in the range 0 to 6 that reponds to the specific solicited MCS feedback request. If the Unsolicited MFB subfield is 1, the PPDU-Type subfield contains the Packet Format and Coding Type subfields as shown in Figure XXX. The Packet Format subfield indicates the packet format of the PPDU from which the unsolicited MFB was estimated: Set to 0 for HE_SU Set to 1 for HE_MU Set to 2 for HE_EXT_SU Set to 3 for HE_TRIG The Coding Type subfield contains the Coding information (0 for BCC and 1 for LDPC) of the PPDU from which the unsolicited MFB was estimated.
Tx BF	Transmission type of the measured PPDU	If the Unsolicited MFB subfield is 1, Tx BF subfield indicates if the PPDU from which the unsolicited MFB was estimated is beamformed or not. Set to 0 for non-beamformed PPDU Set to 1 for beamformed PPDU Otherwise, this subfield is reserved.

The format of the MSI/PPDU Type subfield is defined in Figure 9-15f (MSI/PPDU Type subfield when the Unsolicited MFB subfield is 1).

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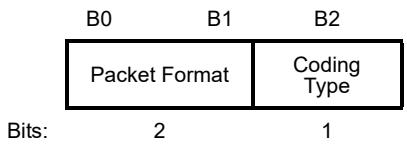


Figure 9-15f—MSI/PPDU Type subfield when the Unsolicited MFB subfield is 1

9.2.4.6.4.5 BSR Control

The Control Information subfield, when the Control ID subfield is 3, contains buffer status information used for UL MU operation (see 27.5.3.6 (HE buffer status feedback operation for UL MU)). The format of the subfield is shown in Figure 9-15g (Control Information subfield format when Control ID subfield is 3).



Figure 9-15g—Control Information subfield format when Control ID subfield is 3

The ACI Bitmap subfield indicates the access categories for which the buffer status is reported and its encoding is shown in Table 9-18d (ACI Bitmap subfield encoding). Each bit of the ACI Bitmap subfield is

B0	B1	B2	B3
AC_BK	AC_BE	AC_VI	AC_VO

Table 9-18d—ACI Bitmap subfield encoding

set to 1 to indicate that the buffer status of the corresponding AC, and set to 0 otherwise. When the ACI Bitmap subfield is 0 and the Delta TID subfield is 3 it indicates that there is buffered traffic for all 8 TIDs (see Table 9-18e (Delta TID subfield encoding)).

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The Delta TID subfield, together with the values of the ACI Bitmap subfield, indicate the number of TIDs for which the STA is reporting the buffer status. The encoding of the Delta TID subfield is defined in Table 9-18e (Delta TID subfield encoding).

Table 9-18e—Delta TID subfield encoding

Number of bits in the ACI Bitmap subfield that are set to 1	Mapping of Delta TID subfield value and number of TIDs, N_{TID}
0	Values 0 to 2 are not applicable; Value 3 indicates 8 TIDs (i.e., all ACs have traffic)
1	Value 0 indicates 1 TID; Value 1 indicates 2 TIDs; Values 2 to 3 are not applicable;
2	Value 0 indicates 2 TID; Value 1 indicates 3 TIDs; Value 2 indicates 4 TIDs; Value 3 is not applicable;
3	Value 0 indicates 3 TID; Value 1 indicates 4 TIDs; Value 2 indicates 5 TIDs; Value 3 indicates 6 TIDs;
4	Value 0 indicates 4 TID; Value 1 indicates 5 TIDs; Value 2 indicates 6 TIDs; Value 3 indicates 7 TIDs;
NOTE—The number of TIDs can be obtained as $N_{TID} = N_{ones} + D_{Val}$, where N_{ones} is the number of bits set to one in the AC Bitmap subfield, and D_{Val} is the value of the Delta TID subfield except when N_{ones} is equal to 0 for which there is the $N_{TID} = 8$ case.	

The ACI High subfield indicates the ACI of the AC for which the BSR is indicated in the Queue Size High subfield. The ACI to AC mapping is shown in Table 9-18d (ACI Bitmap subfield encoding).

NOTE—It is up to the non-AP STA that reports the buffer status to determine which queue deserves higher priority with respect to the other queues. The determination might be based on the time the traffic has been outstanding, QoS delay requirements, amount of buffered traffic, etc., and is out of scope for this standard.

The Scaling Factor subfield indicates the unit *SF*, in octets, of the Queue Size High and Queue Size All subfields. The encoding of the Scaling Factor subfield is shown in Table 9-18f (Scaling Factor subfield encoding).

Table 9-18f—Scaling Factor subfield encoding

Scaling Factor subfield	Scaling factor, *SF*, in octets
0	16
1	256
2	2 048
3	32 768

The Queue Size High subfield indicates the amount of buffered traffic, in units of *SF* octets, for the AC identified by the ACI High subfield that is intended for the STA identified by the receive address of the frame containing the BSR Control field.

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The Queue Size All subfield indicates the amount of buffered traffic, in units of *SF* octets, for all the ACs identified by the ACI Bitmap subfield that is intended for the STA identified by the receive address of the frame containing the BSR Control field.

The queue size values in the Queue Size High and Queue Size All subfields are the total sizes, rounded up to the nearest multiple of *SF* octets, of all MSDUs and A-MSDUs buffered at the STA (including the MSDUs or A-MSDUs contained in the (A-)MPDU containing the BSR) in the delivery queues used for MSDUs and A-MSDUs with AC(s) that are specified in the ACI High and ACI Bitmap subfields, respectively. A queue size value of 254 is used for all sizes greater than 254 × *SF* octets. A queue size value of 255 is used to indicate an unspecified or unknown size. If an MSDU or A-MSDU is fragmented and is not carried in an A-MPDU, the queue size value might remain constant in all fragments even if the amount of queued traffic changes as successive fragments are transmitted. If an MSDU or A-MSDU is fragmented and is carried in an A-MPDU, the queue size values are set according to the rules in 10.13.1 (A-MPDU operation).

9.2.4.6.4.6 UPH Control

The Control Information subfield, when the Control ID subfield is 4, contains the UL power headroom (UPH) used for power pre-correction (see 27.5.3.3 (STA behavior for UL MU operation)). The format of the subfield is shown in Figure 9-15h (Control Information subfield format when the Control ID subfield is 4).

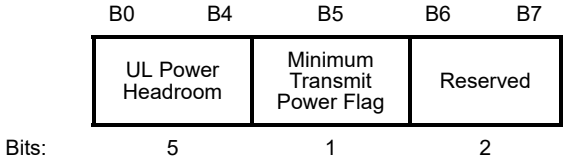


Figure 9-15h—Control Information subfield format when the Control ID subfield is 4

The UL Power Headroom subfield indicates the available power headroom in units of dB, for the current MCS. The resolution for the UL power headroom reported in UL Power Headroom subfield is 1 dB. The UL Power Headroom subfield carries a value 0 to 31 that maps to 0 dB to 31 dB.

The Minimum Transmit Power Flag subfield indicates that the minimum transmit power for the current MCS is reached by the STA. The Minimum Transmit Power Flag subfield is set to 1 to indicate that the minimum transmit power for the current MCS is reached by the STA and set to 0 otherwise.

9.2.4.6.4.7 BQR Control

The Control Information subfield, when the Control ID subfield is 5, contains the bandwidth query report (BQR) used for bandwidth query report operation to assist HE MU transmission (see 27.5.2 (HE bandwidth query report operation for MU)). The format of the subfield is shown in Figure 9-15i (Control Information subfield format when the Control ID subfield is 5).

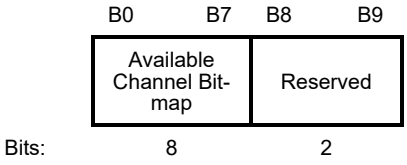


Figure 9-15i—Control Information subfield format when the Control ID subfield is 5

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The Available Channel Bitmap subfield contains a bitmap indicating which subchannels are available at the STA transmitting the BQR. Each bit in the bitmap corresponds to a 20 MHz subchannel within the operating channel width of the BSS with which the STA is associated, with the LSB corresponding to the lowest numbered operating subchannel of the BSS. The bit in position X in the bitmap is set to 1 to indicate that the subchannel $X+1$ is idle; otherwise it is set to 0 to indicate that the subchannel is busy or unavailable. Availability of each 20 MHz subchannel is based on ED rules which are defined in 28.3.19.6.5 (Per 20 MHz CCA sensitivity).

9.2.4.6.4.8 CAS Control

The Control Information subfield, when the Control ID subfield is 6, contains the Command and Status (CAS) Control. The format of the subfield frame is shown in Figure 9-15j (Control Information subfield format when the Control ID subfield is 6).

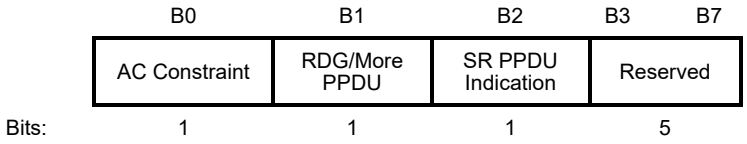


Figure 9-15j—Control Information subfield format when the Control ID subfield is 6

The AC Constraint subfield is defined in Table 9-10 (AC Constraint subfield values), except that a value of 1 indicates to an HE STA that the response can contain RD Data frames from the same AC or higher ACs as defined in 10.28.4 (Rules for RD responder).

The RDG/More PPDU subfield is defined in Table 9-11 (RDG/More PPDU subfield values).

The SR PPDU Indication subfield indicates whether the PPDU carrying the MPDU carrying the CAS Control subfield is an SR PPDU. The SR PPDU Indication is set to 1 when the PPDU is an SR PPDU; otherwise it is set to 0.

9.2.4.7 Frame Body field

9.2.4.7.1 General

Change as Table 9-19 (Maximum data unit sizes (in octets) and durations (in microseconds)) follows:

Table 9-19—Maximum data unit sizes (in octets) and durations (in microseconds)

	Non-HT non-VHT non-DMG PPDU and non-HT duplicate PPDU	HT PPDU	VHT PPDU	HE PPDU	DMG PPDU
MMPDU size	2304	2304	See NOTE 1	See NOTE 1	2304
MSDU size	2304	2304	2304	2304	7920

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Table 9-19—Maximum data unit sizes (in octets) and durations (in microseconds) *(continued)*

	Non-HT non-VHT non-DMG PPDU and non-HT duplicate PPDU	HT PPDU	VHT PPDU	HE PPDU	DMG PPDU
A-MSDU size	3839 or 4065 (see NOTE 2) (HT STA, see also Table 9-162 (Subfields of the HT Capability Information field)), or N/A (non-HT STA, see also 10.12 (A-MSDU operation))	3839 or 7935 (see also Table 9-162 (Subfields of the HT Capability Information field))	See NOTE 3	See NOTE 3	7935
MPDU size	See NOTE 4	See NOTE 5	3895 or 7991 or 11 454 (see also Table 9-249 (Subfields of the VHT Capabilities Information field))	3895 or 7991 or 11 454 (see also Table 9-249 (Subfields of the VHT Capabilities Information field))	See NOTE 5
PSDU size (see NOTE 7)	2^{12}–1 (see Table 15-5 (DSSS PHY characteristics), Table 16-4 (HR/DSSS PHY characteristics), Table 17-21 (OFDM PHY characteristics), Table 18-5 (ERP characteristics))	2^{16}–1 (see Table 19-25 (HT PHY characteristics))	4 692 480 (~$2^{22.16}$) (see Table 21-29 (VHT PHY characteristics))	6,500,631 (~$2^{22.63}$) (see Table 28-50 (HE PHY characteristics))	2^{18}–1 (see Table 20-32 (DMG PHY characteristics))

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Table 9-19—Maximum data unit sizes (in octets) and durations (in microseconds) *(continued)*

	Non-HT non-VHT non-DMG PPDU and non-HT duplicate PPDU	HT PPDU	VHT PPDU	HE PPDU	DMG PPDU
PPDU duration (see NOTE 7)	See NOTE 6	5484 (HT_MF; see 10.26.4 (L_LENGTH and L_DATARATE parameter values for HT-mixed format PPDUs)) or 10 000 (HT_GF; see Table 19-25 (HT PHY characteristics))	5484 (see Table 21-29 (VHT PHY characteristics))	5484 (see Table 28-50 (HE PHY characteristics))	2000 (see Table 20-32 (DMG PHY characteristics))

NOTE 1—No direct constraint on the maximum MMPDU size; indirectly constrained by the maximum MPDU size (see 9.3.3.3 (Beacon frame format)).

NOTE 2—Indirect constraint from the maximum PSDU size: 2^{12}–1 octets minus the minimum QoS Data frame overhead (26 octets for the MAC header and 4 octets for the FCS).

NOTE 3—No direct constraint on the maximum A-MSDU size; indirectly constrained by the maximum MPDU size.

NOTE 4—No direct constraint on the maximum MPDU size; indirectly constrained by the maximum MSDU/MMPDU or (for HT STAs only) A-MSDU size.

NOTE 5—No direct constraint on the maximum MPDU size; indirectly constrained by the maximum A-MSDU size.

NOTE 6—No direct constraint on the maximum duration, but an L_LENGTH value above 2332 might not be supported by some receivers (see last NOTE in 10.26.4 (L_LENGTH and L_DATARATE parameter values for HT-mixed format PPDUs)).

NOTE 7—The values for maximum PSDU size and maximum PPDU duration are informative only. References to the normative requirements are provided.

9.2.5 Duration/ID field (QoS STA)

9.2.5.2 Setting for single and multiple protection under enhanced distributed channel access (EDCA)

Change the 2nd paragraph as follows:

The STA selects between single and multiple protection when it transmits the first frame of a TXOP. All subsequent frames transmitted by the STA in the same TXOP use the same class of duration settings. A STA always uses multiple protection in a TXOP that includes:

- Frames that have the RDG/More PPDU subfield equal to 1
- PSMP frames
- VHT NDP Announcement frames or Beamforming Report Poll frames
- HE NDP Announcement frames or BRP Trigger frame

Change item a) of the 3rd paragraph as follows:

The Duration/ID field is determined as follows:

a) Single protection settings.

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1) For an RTS frame that is not part of a dual clear-to-send (CTS) exchange and is not part of a BDT exchange, the Duration/ID field is set to the estimated time, in microseconds, required to transmit the pending frame, plus one CTS frame, plus one Ack or BlockAck frame if required, plus any NDPs required, plus explicit feedback if required, plus applicable IFSs.

1a) In an MU-RTS Trigger frame, the Duration/ID field is set to the estimated time, in microseconds, required to transmit the pending frame, plus one CTS frame, plus the time to transmit the solicited HE TB PPDU if required, plus the time to transmit the acknowledgement for the solicited HE TB PPDU if required, plus applicable IFSs.

...

3 In a BlockAckReq frame, the Duration/ID field is set to the estimated time required to transmit one Ack or BlockAck frame, as applicable, plus one SIFS.

3a In an MU-BAR Trigger frame, BSRP Trigger frame, GCR MU-BAR Trigger frame and BQRP Trigger frame, the Duration/ID field is set to the time required to transmit the solicited HE TB PPDU plus one SIFS.

...

6) In individually addressed QoS Data frames with the Ack Policy subfield equal to No Ack or Block Ack, for Action No Ack frames, and for group addressed frames, the Duration/ID field is set to one of the following:

i) i) If the frame is the final fragment of the TXOP, 0

ii) ii) Otherwise, the estimated time required for the transmission of the following frame and its response frame, if required (including appropriate IFSs)

7) In a Basic Trigger frame, the Duration/ID field is set to the estimated time required to transmit the solicited HE TB PPDU, plus the estimated time required to transmit the acknowledgement for the solicited HE TB PPDU, plus applicable SIFSs.

Change item b) of the 3rd paragraph as follows:

b) Multiple protection settings. The Duration/ID field is set to a value D as follows:

4) Else $T_{END-NAV} - T_{PPDU} \le D \le T_{TXOP-REMAINING} - T_{PPDU}$

where

$T_{SINGLE\text{-}MSDU}$ is the estimated time required for the transmission of the allowed frame exchange sequence defined in 10.22.2.8 (TXOP limits) (for a TXOP limit of 0), including applicable IFS durations

$T_{PENDING}$ is the estimated time required for the transmission of

—Pending MPDUs of the same AC

—Any associated immediate response frames

—Any HT NDP, VHT NDP, HE NDP or Beamforming Report Poll frame transmissions and explicit feedback response frames

—Applicable IFSs

—Any RDG

—Any pending QoS Null frame exchanges by paged STAs

—Any pending PS-Poll or NDP PS-Poll frame exchanges by paged STAs

—Any DL MU PPDUs

—Any HE TB PPDUs

—Any Trigger frames to solicit HE TB PPDUs

T_{TXOP} is the duration given by dot11EDCATableTXOPLimit (dot11QAPEDCATableTXOPLimit for the AP) for that AC

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$T_{TXOP\text{-}REMAINING}$ is T_{TXOP} less the time already used time within the TXOP

$T_{END\text{-}NAV}$ is the remaining duration of any NAV set by the TXOP holder, or 0 if no NAV has been established

T_{PPDU} is the time required for transmission of the current PPDU

9.2.5.7 Setting for control response frames

Change as follows:

This subclause describes how to set the Duration/ID field for CTS, Ack, and BlockAck frames transmitted by a QoS STA.

In a CTS frame that is not part of a dual CTS sequence transmitted in response to an RTS frame, the Duration/ID field is set to the value obtained from the Duration/ID field of the RTS frame that elicited the response minus the time, in microseconds, between the end of the PPDU carrying the RTS frame and the end of the PPDU carrying the CTS frame.

In a CTS frame that is transmitted in response to an MU-RTS Trigger frame, the Duration/ID field is set to the value obtained from the Duration/ID field of the MU-RTS Trigger frame that elicited the CTS frame minus the time, in microseconds, between the end of the PPDU carrying the MU-RTS Trigger frame and the end of the PPDU carrying the CTS frame.

In an Ack frame, the Duration/ID field is set to the value obtained from the Duration/ID field of the frame that elicited the response minus the time, in microseconds between the end of the PPDU carrying the frame that elicited the response and the end of the PPDU carrying the Ack frame.

In a BlockAck frame transmitted in response to a BlockAckReq or MU-BAR Trigger frame or transmitted in response to a frame containing an implicit block ack request, the Duration/ID field is set to the value obtained from the Duration/ID field of the frame that elicited the response minus the time, in microseconds between the end of the PPDU carrying the frame that elicited the response and the end of the PPDU carrying the BlockAck frame.

In a BlockAck frame transmitted in response to a frame carried in HE TB PPDU, the rule of setting Duration/ID field is described in 9.2.5.2 (Setting for single and multiple protection under enhanced distributed channel access (EDCA)).

9.2.5.8 Setting for other response frames

Change as follows:

In any frame transmitted by a STA that is not the TXOP holder and is not specified by 9.2.5.1 to 9.2.5.7, the Duration/ID field is set to the value obtained from the Duration/ID field of the frame that elicited the response minus the time, in microseconds, between the end of the PPDU carrying the frame that elicited the response and the end of the PPDU carrying the frame. When the frame is contained in an HE TB PPDU, the time is equal to SIFS plus the duration of the HE TB PPDU, where the duration of the HE TB PPDU which is defined in Equation (28-126).

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9.3 Format of individual frame types

9.3.1 Control frames

9.3.1.2 RTS frame format

Change the 3rd paragraph as follows:

The TA field is the address of the STA transmitting the RTS frame or the bandwidth signaling TA of the STA transmitting the RTS frame. In an RTS frame transmitted by a VHT STA or an HE STA in a non-HT or non-HT duplicate format and where the scrambling sequence carries the TXVECTOR parameters CH_BANDWIDTH_IN_NON_HT and DYN_BANDWIDTH_IN_NON_HT (see 10.3.2.6 (VHT RTS procedure)), the TA field is a bandwidth signaling TA.

9.3.1.3 CTS frame format

Change the 2nd paragraph of this subclause as follows:

When the CTS frame is a response to an RTS frame, the value of the RA field of the CTS frame is set to the address from the TA field of the RTS frame with the Individual/Group bit forced to the value 0. When the CTS frame is a response to an MU-RTS Trigger frame, the value of the RA field of the CTS frame is set to the address from the TA field of the MU-RTS Trigger frame.

9.3.1.5 PS-Poll frame format

Change the 2nd paragraph as follows:

The BSSID is the address of the STA contained in the AP. The TA field is the address of the STA transmitting the frame or a bandwidth signaling TA. In a PS-Poll frame transmitted by a VHT STA or an HE STA in a non-HT or non-HT duplicate format and where the scrambling sequence carries the TXVECTOR parameter CH_BANDWIDTH_IN_NON_HT, the TA field value is a bandwidth signaling TA. The ID field contains the AID value assigned to the STA transmitting the frame by the AP in the (Re)Association Response frame that established that STA's current association, with the two MSBs set to 1.

9.3.1.6 CF-End frame format

Change the last paragraph as follows:

When transmitted by a non-DMG STA, the BSSID (TA) field is the address of the STA contained in the AP except that the Individual/Group bit of the BSSID (TA) field is set to 1 in a CF-End frame transmitted by a VHT STA to a VHT AP or an HE STA to an HE AP in a non-HT or non-HT duplicate format to indicate that the scrambling sequence carries the TXVECTOR parameter CH_BANDWIDTH_IN_NON_HT. When transmitted by a DMG STA, the TA field is the MAC address of the STA transmitting the frame.

9.3.1.8 BlockAckReq frame format

9.3.1.8.1 Overview

Change the 4th paragraph as follows:

The TA field value is the address of the STA transmitting the BlockAckReq frame or a bandwidth signaling TA. In a BlockAckReq frame transmitted by a VHT STA or an HE STA in a non-HT or non-HT duplicate format and where the scrambling sequence carries the TXVECTOR parameter CH_BANDWIDTH_IN_NON_HT, the TA field value is a bandwidth signaling TA.

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9.3.1.9 BlockAck frame format

9.3.1.9.1 Overview

Change Figure 9-33 as follows:

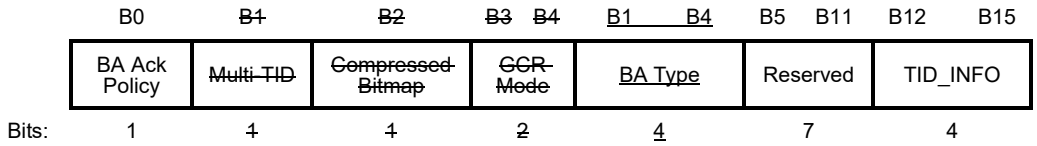


Figure 9-33—BA Control field

Change the 3rd paragraph as follows:

The RA field of ~~the BlockAck frame is the address of the recipient STA~~ a BlockAck frame that is not a Multi-STA BlockAck variant is set to the TA field of the soliciting frame or the address of the recipient STA whose data frames are acknowledged.

Change the 4th paragraph as follows:

The TA field value is the address of the STA transmitting the BlockAck frame or a bandwidth signaling TA in the context of HT-delayed Block Ack. In a BlockAck frame transmitted in the context of HT-delayed Block Ack by a VHT STA or an HE STA in a non-HT or non-HT duplicate format and where the scrambling sequence carries the TXVECTOR parameter CH_BANDWIDTH_IN_NON_HT, the TA field value is a bandwidth signaling TA.

Change the 6th paragraph of this subclause as follows:

For BlockAck frames sent under Delayed and HT-delayed agreements, the BA Ack Policy subfield of the BA Control field has the meaning shown in Table 9-23 (BA Ack Policy subfield). For BlockAck frames sent under other types of agreement, the BA Ack Policy subfield is reserved. An HE STA does not send a Multi-STA BlockAck frame under Delayed and HT-delayed agreements.

Change the 7th paragraph of this subclause as follows:

The ~~values of the Multi-TID, Compressed Bitmap, and GCR Mode subfields~~ BA Type subfield of the BA Control field determines which of the possible BlockAck frame variants is represented, as indicated in the Table 9-24 (BlockAck frame variant encoding).

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Change Table 9-24 as follows:

Table 9-24—BlockAck frame variant encoding

~~Multi-TID subfield value~~	~~Compressed Bitmap subfield value~~	~~GCR Mode subfield value (B3 B4)~~	BA Type (B1 B2 B3 B4)	BlockAck frame variant
~~0~~	~~0~~	~~00~~	0000	Basic BlockAck
		~~01~~	0001	Reserved
		~~10~~	0010	Reserved
		~~11~~	0011	Reserved
~~0~~	~~1~~	~~00~~	0100	Compressed BlockAck
		~~01~~	0101	GLK-GCR BlockAck
		~~10~~	0110	GCR BlockAck
		~~11~~	0111	Reserved
~~1~~	~~0~~	~~00~~	1000	Extended Compressed BlockAck
		~~01~~	1001	Reserved
		~~10~~	1010	Reserved
		~~11~~	1011	Reserved
~~1~~	~~1~~	~~00~~	1100	Multi-TID BlockAck
		~~01~~	1101	~~Reserved~~ Multi-STA BlockAck
		~~10~~	1110	Reserved
		~~11~~	1111	Reserved

Change the 8th paragraph as follows:

~~The GCR Mode subfield indicates whether the BlockAck frame was sent in response to a GCR Mode BlockAckReq or a GLK-GCR BlockAckReq frame. The GCR Mode subfield is 10 when the BlockAck frame is sent in response to a GCR BlockAckReq frame, 01 when the BlockAck frame is sent in response to a GLK-GCR BlockAckReq, and 00 otherwise.~~ A GCR BlockAck frame is sent in response to a GCR BlockAckReq frame and a GLK-GCR BlockAck frame is sent in response to a GLK-GCR BlockAckReq frame.

9.3.1.9.3 Compressed BlockAck variant

Change subclause 9.3.1.9.3 (including Figure 9-34) as follows:

The TID_INFO subfield of the BA Control field of the Compressed BlockAck frame contains the TID for which this BlockAck frame is sent.

The BA Information field of the Compressed BlockAck frame comprises the Block Ack Starting Sequence Control subfield and the Block Ack Bitmap subfield, as shown in Figure 9-35 (BA Information field (Compressed BlockAck)). The Starting Sequence Number subfield of the Block Ack Starting Sequence Control

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subfield contains the sequence number of the first MSDU or A-MSDU for which this BlockAck frame is sent. The value of this subfield is defined in 10.24.7.5 (Generation and transmission of BlockAck frames by an HT STA or DMG STA). ~~The Fragment Number subfield of the Block Ack Starting Sequence Control subfield is set to 0.~~

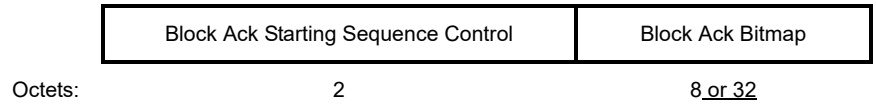


Figure 9-35—BA Information field (Compressed BlockAck)

The Fragment Number subfield of the Block Ack Starting Sequence Control field is set as defined in Table 9-24a (Fragment Number subfield encoding for the Compressed BlockAck variant)

Insert the following table:

Table 9-24a—Fragment Number subfield encoding for the Compressed BlockAck variant

Fragment Number subfield			Fragmentation Level 3 (ON/ OFF)	Block Ack Bitmap subfield length (octets)	Maximum number of MSDUs/A-MSDUs that can be acknowledged
B3	B2-B1	B0			
0	0	0	OFF	8	64
0	1	0		Reserved	Reserved
0	2	0		32	256
0	3	0		Reserved	Reserved
0	0	1	ON	8	16
0	1	1		Reserved	Reserved
0	2	1		32	64
0	3	1		Reserved	Reserved
1	Any	Any		Reserved	Reserved

NOTE—A Compressed BlockAck frame with B0 of the Fragment Number subfield set to 1 is not sent to an HE STA whose HE Fragmentation Support subfield in the HE Capabilities element it transmits is not set to 3 (see 27.3 (Fragmentation and defragmentation)).

Change the remainder of 9.3.1.9.3 as follows:

When B0 of the Fragment Number subfield is 0, the Block Ack Bitmap subfield of the BA Information field of the Compressed BlockAck frame is used to indicate the receive status of up to 64 or 256 MSDUs or A-MSDUs depending upon the value of B2-B1 in the Fragment Number subfield as shown in Table 9-24a (Fragment Number subfield encoding for the Compressed BlockAck variant).~~The Block Ack Bitmap subfield of the BA Information field of the Compressed BlockAck frame is 8 octets in length and is used to indicate the received status of up to 64 MSDUs and A-MSDUs.~~ Each bit that is equal to 1 in the compressed Block Ack Bitmap subfield acknowledges the successful reception of a single MSDU or A-MSDU in the

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order of sequence number, with the first bit of the Block Ack Bitmap subfield corresponding to the MSDU or A-MSDU or fragment thereof with the sequence number that matches the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield.

When B0 of the Fragment Number subfield is 1, the Block Ack Bitmap subfield of the BA Information field of the Compressed BlockAck frame is used to indicate the receive status of up to 16 or 64 MSDUs and A-MSDUs depending upon the value B2-B1 in the Fragment Number subfield as shown in Table 9-24a (Fragment Number subfield encoding for the Compressed BlockAck variant). If bit position *n* of the Block Ack Bitmap subfield is 1, it acknowledges receipt of an MPDU with sequence number value *SN* and fragment number value *FN* with $n = 4 \times (SN - SSN) + FN$, where *SSN* is the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield and the operations on the sequence numbers are performed modulo 4096. If bit position *n* of the Block Ack Bitmap subfield is 0, it indicates that the MPDU has not been received.

NOTE—When the B0 of the Fragment Number subfield is equal to 1 then the Block Ack Bitmap subfield is split into (Block Ack Bitmap subfield length)/4 subbitmaps, each of which indicates receive status for 4 fragments of each of the MSDUs as indicated in Table 9-24a (Fragment Number subfield encoding for the Compressed BlockAck variant).

9.3.1.9.6 GCR Block Ack variant

Change the 3rd paragraph as follows:

The GCR Group Address subfield is set to the value from the Group Address subfield of the GCR BAR Information field in the BlockAckReq frame to which the BlockAck frame is sent in response. When the BlockAck frame is sent in response to the GCR MU-BAR Trigger frame, the GCR Group Address subfield is set to the value from the RA field in the GCR MU-BAR Trigger frame.

Insert a new subclause after 9.3.1.9.6:

9.3.1.9.7 Multi-STA BlockAck variant

The Multi-STA BlockAck frame is supported if either UL MU or multi-TID A-MPDU operation is supported and is used to acknowledge multi-STA multi-TID, multi-STA single TID, or single-STA multi-TID A-MPDUs.

An HE AP that transmits a Multi-STA BlockAck frame with different values of the AID11 subfield in Per AID TID Info subfields sets the RA field to the broadcast address. An HE AP that transmits a Multi-STA BlockAck frame with a single Per AID TID Info subfield or with the same values of the AID11 subfield in Per AID TID Info subfields sets the RA field to the address of the recipient STA that solicited the BlockAck frame. A non-AP HE STA that transmits a Multi-STA BlockAck frame with a single AID subfield or with the same values of the AID subfield in Per AID TID Info subfields and sets the RA field to the TA field of the soliciting frame or the address of the recipient STA whose data or management frames are acknowledged.

The TID_INFO subfield of the BA Control field of the Multi-STA BlockAck frame is reserved.

The BA Information field of the Multi-STA BlockAck frame comprises one or more Per AID TID Info subfields as defined in Figure 9-38a (BA Information field format (Multi-STA BlockAck)).

The Per AID TID Info subfield when the AID11 subfield of the AID TID Info subfield is not 2045 is shown in Figure 9-38b (Per AID TID Info subfield format when the AID11 subfield is not 2045).

The Per AID TID Info subfield when the AID11 subfield of the AID TID Info subfield is 2045 is shown in Figure 9-38b (Per AID TID Info subfield format when the AID11 subfield is not 2045).

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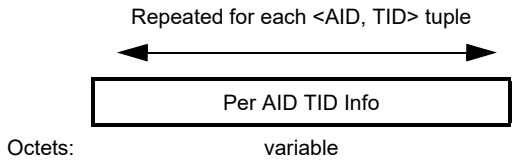


Figure 9-38a—BA Information field format (Multi-STA BlockAck)

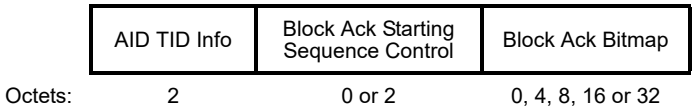


Figure 9-38b—Per AID TID Info subfield format when the AID11 subfield is not 2045

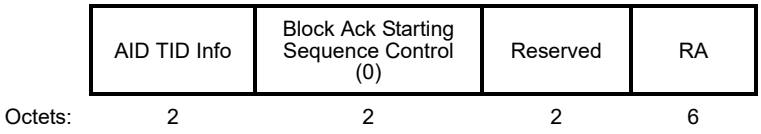


Figure 9-38c—Per AID TID Info subfield format when the AID11 subfield is 2045

Where Block Ack Starting Sequence Control subfield is set to 0 and RA subfield indicates the MAC address of an unassociated STA for which the Per STA Info subfield is intended.

The AID TID Info subfield is shown in Figure 9-38d (AID TID Info subfield format).

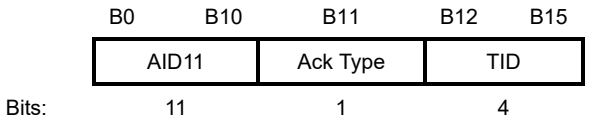


Figure 9-38d—AID TID Info subfield format

The AID11 subfield carries the 11 LSBs of the AID of the non-AP STA for which the Per AID TID Info subfield is intended. If the Multi-STA BlockAck frame is intended for an AP, the AID11 subfield is set to 0. A value 2045 in the AID11 subfield is used as a unique identifier for any unassociated STA. The Ack Type subfield and TID subfield are set to 0 and 15, respectively, when AID11 subfield is set to 2045.

NOTE 1—More than one Per AID TID Info subfield with the same value in the AID11 subfield but different values in the TID subfield can be present in the Multi-STA BlockAck frame.

If the AID11 subfield is not 2045, then the TID subfield contains the TID for which the acknowledgment or block acknowledgment contained in the Per AID TID Info subfield applies and is set as defined in Table 9-

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24b (Context of the Per AID TID Info subfield and presence of optional subfields when the AID11 subfield is not 2045).

Table 9-24b—Context of the Per AID TID Info subfield and presence of optional subfields when the AID11 subfield is not 2045

Ack Type subfield values	TID subfield values	Presence of Block Ack Starting Sequence Control subfield and Block Ack Bitmap subfields	Context of a Per AID TID Info subfield in a Multi-STA BlockAck frame
0	0–7	Present	Block acknowledgment context: Sent as a response to MPDUs in an A-MPDU that solicit an immediate block acknowledgement or to a BlockAckReq frame.
1	0–7	Not present	Acknowledgment context: Sent as a response to an MPDU or S-MPDU that solicits an immediate acknowledgment.
0 or 1	8–13	N/A	Reserved
0	14	N/A	Reserved
1	14	Not present	All-ack context: Sent as a response to an A-MPDU that solicits an immediate response and all MPDUs contained in the A-MPDU are received successfully.
0	15	N/A	Reserved
1	15	Not present	Action frame/PS-Poll acknowledgment context: Sent as a response to an Action frame carried in an A-MPDU, or PS-Poll frame in an S-MPDU that solicits an immediate acknowledgment.
NOTE—Additional rules for acknowledgement, block acknowledgment and all-ack are defined in 27.4.2 (Acknowledgement context in a Multi-STA BlockAck frame) for a multi-TID A-MPDU.			

If the ACK Type subfield is 0 and the TID value of the Per AID TID Info subfield is 15, then the Block Ack Starting Sequence Control, 2 octets reserved and RA fields are present and the Per AID TID Info field acknowledges a Management frame sent by an unassociated non-AP STA.

If the Ack Type subfield is 1 and the TID value of the AID TID Info subfield is less than 8 or equal to 15, then the Block Ack Starting Sequence Control and Block Ack Bitmap subfields are not present and the Per AID TID Info subfield acknowledges successful reception of a single MPDU indicated by the TID of the AID TID Info subfield. If the Ack Type subfield is 1 and the TID subfield of the AID TID Info subfield is 14, then the Block Ack Starting Sequence Control and Block Ack Bitmap are not present and the Per AID TID Info subfield acknowledges successful reception of all the MPDUs carried in the eliciting A-MPDU. The responding STA determines that all the MPDUs carried in the eliciting A-MPDU are successfully received if the all the MPDUs that precede the first MPDU delimiter with EOF equal to 1 and MPDU Length field equal to 0 are received successfully. The Ack Type subfield is not set to 1 when responding to an MU-BAR Trigger frame. If the Ack Type subfield is 0 and the TID value of the Per AID TID Info subfield is smaller than 8, then the Block Ack Starting Sequence Control and Block Ack Bitmap subfields are present.

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The context and the presence of each optional subfield in a Per AID TID Info subfield in a Multi-STA BlockAck frame is defined in Table 9-24b (Context of the Per AID TID Info subfield and presence of optional subfields when the AID11 subfield is not 2045).

If the Ack Type subfield is 0, the Fragment Number subfield encoding indicates the length of the BlockAck bitmap subfield as defined in Table 9-24c (Fragment Number subfield encoding for the Multi-STA Block-Ack variant).

Table 9-24c—Fragment Number subfield encoding for the Multi-STA BlockAck variant

Fragment Number subfield			Fragmentation Level 3 (ON/ OFF)	Block Ack Bitmap subfield length (octets)	Maximum number of MSDUs/A-MSDUs that can be acknowledged
B3	B2 B1	B0			
0	0	0	OFF	8	64
0	1	0		16	128
0	2	0		32	256
0	3	0		4	32
0	0	1	ON	8	16
0	1	1		16	32
0	2	1		32	64
0	3	1		4	8
1	Any	Any		Reserved	Reserved
NOTE—A Multi-STA BlockAck frame with B0 of the Fragment Number subfield set to 1 can only be sent to an HE STA whose HE Fragmentation Support subfield in the HE Capabilities element it transmits is 3 (see 27.3 (Fragmentation and defragmentation)).					

When B0 of the Fragment Number subfield of the Block Ack Starting Sequence Control subfield is 0, the BA Information field of the Multi-STA BlockAck frame contains an 8-octet, 16-octet, 32-octet or 4-octet Block Ack Bitmap subfield depending on B2-B1 of the Fragment Number subfield as defined in Table 9-24c (Fragment Number subfield encoding for the Multi-STA BlockAck variant) indicating the receive status of up to 64, 128, 256 or 32 MSDUs or A-MSDUs respectively. Each bit that is equal to 1 in the Block Ack Bitmap subfield acknowledges the successful reception of a single MSDU or A-MSDU in the order of sequence number with the first bit of the Block Ack Bitmap subfield corresponding to the MSDU or A-MSDU with the sequence number that matches the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield.

When B0 of the Fragment Number subfield of the Block Ack Starting Sequence Control subfield is 1, the Block Ack Bitmap subfield of the BA Information field of the Multi-STA Block Ack frame is used to indicate the receive status of up to 16, 32, 64 or 8 MSDUs or A-MSDUs depending on B2-B1 of the Fragment Number subfield as shown in Table 9-24c (Fragment Number subfield encoding for the Multi-STA Block-Ack variant). If bit position n of the Block Ack Bitmap subfield is 1, it acknowledges receipt of an MPDU with sequence number value SN and fragment number value FN with $n = 4 \times (SN - SSN) + FN$, where SSN is the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield and the operations on the sequence numbers are performed modulo 4096. If bit position n of the Block Ack Bitmap subfield is 0, it indicates that the MPDU has not been received.

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NOTE 2—When B0 of the Fragment Number subfield is 1 then the Block Ack Bitmap field is split into Block Ack Bitmap field length/4 subbitmaps, each of which indicates receive status for 4 fragments of each of the MSDUs as indicated in Table 9-24c (Fragment Number subfield encoding for the Multi-STA BlockAck variant). For an A-MSDU, only the first bit of the subbitmap is used, when fragmentation is not allowed in an A-MSDU.

Change the title of 9.3.1.20 as follows:

9.3.1.20 VHT/HE NDP Announcement frame format

Insert the following at the end of 9.3.1.20:

The HE NDP Announcement uses the same Frame Control subtype as the VHT NDP Announcement. The frame format of the HE NDP Announcement frame is shown in Figure 9-51a (HE NDP Announcement frame format).

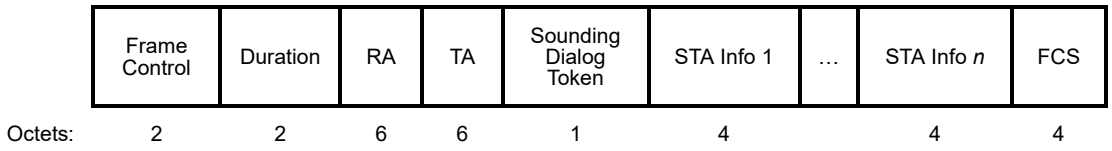


Figure 9-51a—HE NDP Announcement frame format

The Duration, RA, TA and Sounding Dialog Token fields are set as in a VHT NDP Announcement frame, except that bit 1 of the Sounding Dialog Token is set to 1 to indicate an HE NDP Announcement frame.

The format of the STA Info field in an HE NDP Announcement Frame is defined in Figure 9-51b (STA Info subfield format in an HE NDP Announcement frame).

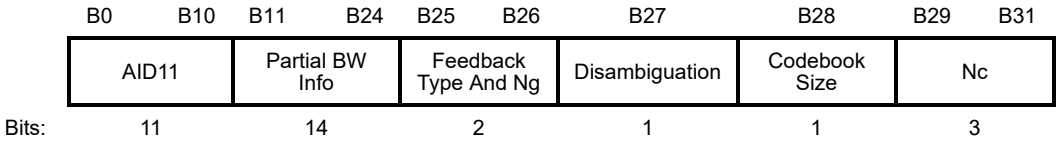


Figure 9-51b—STA Info subfield format in an HE NDP Announcement frame

An HE NDP Announcement frame contains at most 1 STA Info field per STA.

The AID11 subfield contains the 11 least significant bits of the AID of a STA expected to process the following HE NDP and prepare the sounding feedback.

The Partial BW Info subfield is defined in Figure 9-51c (Partial BW Info subfield).

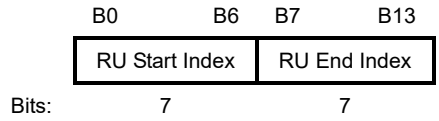


Figure 9-51c—Partial BW Info subfield

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The RU Start Index subfield of the Partial BW subfield indicates the first 26-tone RU for which the HE beamformer is requesting feedback. The RU End Index subfield of the Partial BW subfield indicates the last 26-tone RU for which the HE beamformer is requesting feedback. The 26-tone RU is encoded in increasing order:

— For 20 MHz BW of the HE NDP Announcement frame, RU1 is encoded as 0 and RU9 is encoded as 8. Values 9–127 are reserved. See Table 28-6 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU).

— For 40 MHz BW of the HE NDP Announcement frame (possibly in non-HT Duplicate format), RU1 is encoded as 0 and RU18 is encoded as 17. Values 18–127 are reserved. See Table 28-7 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU).

— For 80 MHz BW of the HE NDP Announcement frame (possibly in non-HT Duplicate format), RU1 is encoded as 0 and RU37 is encoded as 36. Values 37–127 are reserved. See Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU).

— For 80+80 or 160 MHz BW of the HE NDP Announcement frame (possibly in non-HT Duplicate format), RU1 in the lower 80 MHz segment is encoded as 0 and RU37 in the lower 80 MHz segment is encoded as 36. RU1 in the upper 80 MHz segment is encoded as 37 and RU37 in the upper 80 MHz segment is encoded as 73. Values 74–127 are reserved. For 80+80 MHz, feedback is not requested for the gap between the 80 MHz segments. See Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU).

The Feedback Type And Ng and Codebook Size subfields are defined in Table 9-25a (Feedback Type And Ng subfield and Codebook Size subfield encoding).

Table 9-25a—Feedback Type And Ng subfield and Codebook Size subfield encoding

Feedback Type And Ng		Codebook Size	Description
B25	B26	B28	
0	0	0	SU, $Ng = 4$, quantization resolution $(\phi, \psi) = \{4, 2\}$
0	0	1	SU, $Ng = 4$, quantization resolution $(\phi, \psi) = \{6, 4\}$
0	1	0	SU, $Ng = 16$, quantization resolution $(\phi, \psi) = \{4, 2\}$
0	1	1	SU, $Ng = 16$, quantization resolution $(\phi, \psi) = \{6, 4\}$
1	0	0	MU, $Ng = 4$, quantization resolution $(\phi, \psi) = \{7, 5\}$
1	0	1	MU, $Ng = 4$, quantization resolution $(\phi, \psi) = \{9, 7\}$
1	1	0	CQI only feedback
1	1	1	MU, $Ng = 16$, quantization resolution $(\phi, \psi) = \{9, 7\}$

The Disambiguation subfield is set to 1 to prevent a non-HE VHT STA from wrongly determining its AID in the NDP Announcement frame. The Disambiguation subfield coincides with the MSB of the AID12 subfield of an expected VHT NDP Announcement when the HE NDP Announcement field is parsed by a non-HE VHT STA. The MSB of the AID12 subfield is always 0 for a non-HE VHT STA due to the limitation of the AID to a maximum of 2007.

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The Nc field indicates the number of columns Nc, in the Compressed Beamforming Feedback Matrix subfield minus 1, if the requested feedback type is MU. Set to 0 to request *Nc* = 1, set to 1 to request *Nc* = 2, ..., set to 7 to request *Nc* = 8. Reserved if the requested feedback type is SU.

Insert a new subclause after 9.3.1.22:

9.3.1.23 Trigger frame format

The Trigger frame solicits and allocates resources for HE TB PPDU transmissions. The HE TB PPDU transmission starts SIFS after the PPDU that carries the Trigger frame. The Trigger frame also carries other information required by the responding STA to send an HE TB PPDU.

The frame format for the Trigger frame is defined in Figure 9-52c (Trigger frame).

	Frame Control	Duration	RA	TA	Common Info	User Info	...	User Info	Padding	FCS
Octets:	2	2	6	6	8 or more	5 or more		5 or more	variable	4

Figure 9-52c—Trigger frame

The Duration field is set as defined in 9.2.5 (Duration/ID field (QoS STA)).

The RA field of the Trigger frame is the address of the recipient STA(s). The RA field is set to the individual address of the STA if the Trigger frame has only one User Info field containing the 12 LSBs of the AID of the STA in the AID12 field, is set to the broadcast address if the Trigger frame is not a GCR MU-BAR and has either more than one User Info field or has at least one User Info field that allocates random access RUs, and is set to the MAC address of the group for which reception status is being requested if the Trigger frame is GCR MU-BAR.

The TA field is the address of the STA transmitting the Trigger frame when the Trigger frame is addressed to STAs that belong to a single BSS. The TA field is the address of the transmitted BSSID when the Trigger frame is addressed to STAs from at least two different BSSs of the multiple BSSID set. The rules for setting of the TA field are defined in 27.5.3.2.3 (Allowed settings of the Trigger frame fields and UMRS Control field).

The Common Info field is defined in Figure 9-52d (Common Info field).

	B0 B3	B4 B15	B16	B17	B18 B19	B20 B21	B22	B23 B25
	Trigger Type	Length	Cascade Indication	CS Required	BW	GI And LTF Type	MU-MIMO LTF Mode	Number Of HE-LTF Symbols And Midamble Periodicity
Bits:	4	12	1	1	2	2	1	3

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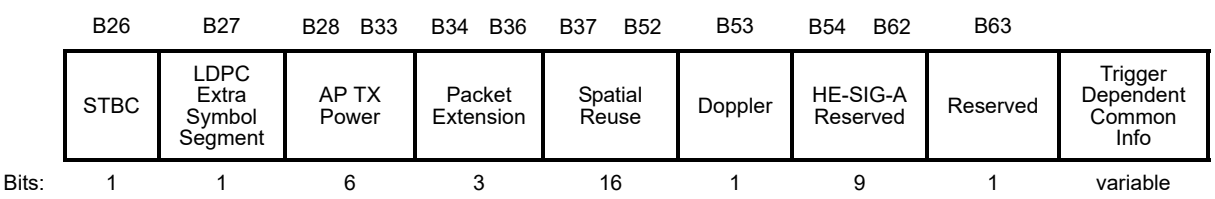


Figure 9-52d—Common Info field

The Trigger Type subfield indicates the type of the Trigger frame and the encoding is defined in Table 9-25b (Trigger Type subfield encoding).

Table 9-25b—Trigger Type subfield encoding

Trigger Type field value	Description
0	Basic Trigger
1	Beamforming Report Poll (BRP)
2	MU-BAR
3	MU-RTS
4	Buffer Status Report Poll (BSRP)
5	GCR MU-BAR
6	Bandwidth Query Report Poll (BQRP)
7	NDP Feedback Report Poll
8-15	Reserved

The Length subfield of the Common Info field indicates the value of the L-SIG Length field of the HE TB PPDU that is the response to the Trigger frame.

The Cascade Indication subfield of the Common Info field is set to 1 to indicate that a subsequent Trigger frame is scheduled for transmission as defined in 27.7 (TWT operation) and in 27.14.2 (Power save with UORA). Otherwise the Cascade Indication subfield is set to 0.

The CS Required subfield of the Common Info field is set to 1 to indicate that the STAs identified in the User Info fields are required to use ED to sense the medium and to consider the medium state and the NAV in determining whether or not to respond. The CS Required subfield is set to 0 to indicate that the STAs identified in the User Info fields are not required to consider the medium state or the NAV in determining whether or not to respond. See 27.5.3.3 (STA behavior for UL MU operation) and 27.5.3.5 (UL MU CS mechanism) for details.

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The BW subfield of the Common Info field indicates the bandwidth in the HE-SIG-A of the HE TB PPDU and is defined in Table 9-25c (BW subfield encoding).

Table 9-25c—BW subfield encoding

BW subfield value	Description
0	20 MHz
1	40 MHz
2	80 MHz
3	80+80 MHz or 160 MHz

The GI And LTF Type subfield of the Common Info field indicates the GI and HE-LTF type of the HE TB PPDU response. The GI And LTF Type subfield encoding is defined in Table 9-25d (GI And LTF Type subfield encoding).

Table 9-25d—GI And LTF Type subfield encoding

GI And LTF field value	Description
0	1x LTF + 1.6 μs GI
1	2x LTF + 1.6 μs GI
2	4x LTF + 3.2 μs GI
3	Reserved

The MU-MIMO LTF Mode subfield of the Common Info field indicates the LTF mode of the UL MU-MIMO HE TB PPDU response. The AP shall set the MU-MIMO LTF Mode subfield to single stream pilots if the triggered UL PPDU contains partial or full UL OFDMA allocation. The MU-MIMO LTF Mode subfield encoding is defined in Table 9-25e (MU-MIMO LTF Mode subfield encoding).

Table 9-25e—MU-MIMO LTF Mode subfield encoding

MU-MIMO LTF subfield value	Description
0	HE single stream pilot HE LTF mode
1	HE masked HE LTF sequence mode

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If the Doppler subfield of the Common Info field is 0, then the Number Of HE-LTF Symbols And Midamble Periodicity subfield of the Common Info field indicates the number of HE-LTF symbols present in the HE TB PPDU that is the response to the Trigger frame minus 1.

If the Doppler subfield of the Common Info field is 1, then B23-B24 of the Number OF HE-LTF Symbols And Midamble Periodicity subfield indicates the number of HE-LTF symbols present in the HE TB PPDU that is the response to the Trigger frame, and B25 of the Number OF HE-LTF Symbols And Midamble Periodicity subfield indicates midamble periodicity in the same HE TB PPDU.

For a non-OFDMA PPDU, the number of HE-LTF symbols is a function of the total number of space-time streams, $N_{STS,total}$ and the encoding of the Number Of HE-LTF Symbols And Midamble Periodicity subfield is defined in Table 21-13.

For an OFDMA PPDU, the number of HE-LTF symbols is greater than or equal to the maximum $N_{STS,total}$ across all allocated RUs and the encoding of the Number Of HE-LTF Symbols And Midamble Periodicity subfield is the same as the Number of HE-LTF Symbols field defined in Table 28-19 (HE-SIG-A field of an HE MU PPDU).

The STBC subfield of the Common Info field indicates the status of STBC encoding of the HE TB PPDU that is the response to the Trigger frame. It is set to 1 if STBC encoding is used and set to 0 otherwise.

The LDPC Extra Symbol Segment subfield of the Common Info field indicates the status of the LDPC extra symbol segment. It is set to 1 when LDPC extra symbol segment is present and set to 0 otherwise.

The AP Tx Power subfield of the Common Info field indicates the combined average power per 20 MHz bandwidth referenced to the antenna connector, of all transmit antennas used to transmit the Trigger frame at the HE AP. The resolution for the transmit power reported in the Common Info field is 1 dB. The AP Tx Power subfield encoding is defined in Table 9-25f (AP Tx Power subfield encoding).

Table 9-25f—AP Tx Power subfield encoding

AP Tx Power subfield value	Description
0-60	Values 0 to 60 map to –20 dBm to 40 dBm
61-63	Reserved

The Packet Extension subfield of the Common Info field indicates the PPDU extension (PE) duration of the HE TB PPDU that is the response to the Trigger frame. The structure of the Packet Extension subfield is defined in Figure 9-52e (Packet Extension subfield).

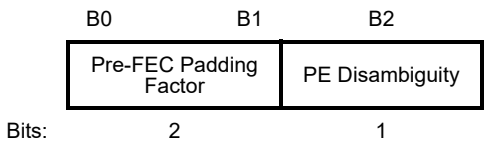


Figure 9-52e—Packet Extension subfield

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The subfields of the Packet Extension subfield are defined in Table 9-25g (Subfields of the Packet Extension subfield)and have the same encoding as their respective subfields in HE SIG-A (see Table 28-20 (HE-SIG-A field of an HE TB PPDU)).

Table 9-25g—Subfields of the Packet Extension subfield

Subfield	Description	Encoding
Pre-FEC Padding Factor	Indicates the pre-FEC padding factor	Set to 0 to indicate a pre-FEC padding factor of 4 Set to 1 to indicate a pre-FEC padding factor of 1 Set to 2 to indicate a pre-FEC padding factor of 2 Set to 3 to indicate a pre-FEC padding factor of 3
PE Disambiguity	Indicates PE disambiguity	Set to 0 to indicate no PE disambiguity Set to 1 to indicate PE disambiguity

The PE Disambiguity subfield shall be set to 1 if the condition in Equation (28-113) is met, otherwise it shall be set to 0.

The Spatial Reuse subfield of the Common Info field carries the value for the Spatial Reuse field in the HE-SIG-A field of the HE TB PPDU that is the response to the Trigger frame. The format of the Spatial Reuse subfield is shown in Figure 9-52f (Spatial Reuse field), where each Spatial Reuse *n* subfield, $1 \le n \le 4$, is set to the same value as its corresponding subfield in the HE-SIG-A of the TB PPDU, which are defined in Table 28-19 (HE-SIG-A field of an HE MU PPDU).

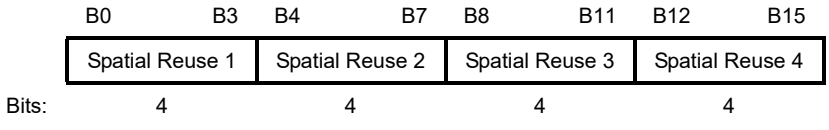


Figure 9-52f—Spatial Reuse field

The Doppler subfield of the Common Info field is set to 1 to indicate that a midamble is present in the HE TB PPDU and set to 0 otherwise.

The HE-SIG-A Reserved subfield of the Common Info field indicates the values of the reserved bits in the HE-SIG-A2 subfield of the HE TB PPDU that is the response to the Trigger frame. Bits B54 to B62 in the Trigger frame are set to 1 and correspond to the bits B7 to B15 in the HE-SIG-A2 subfield of the HE TB PPDU with B54 in the Trigger frame corresponding to B7 in the HE-SIG-A2 subfield of the HE TB PPDU and so on.

The Trigger Dependent Common Info subfield in the Common Info field is optionally present based on the value of the Trigger Type field.

The User Info field is defined in Figure 9-52g (User Info field).

The AID12 subfield of the User Info field carries the 12 LSBs of the AID of the STA for which the User Info field is intended. An AID12 subfield that is 0 or 2045 indicates that the User Info field allocates one or more contiguous RUs for random access (see 27.5.5 (UL OFDMA-based random access (UORA))). An AID12 subfield that is 2046 indicates an unassigned RU (see 27.5.3.2.3 (Allowed settings of the Trigger frame

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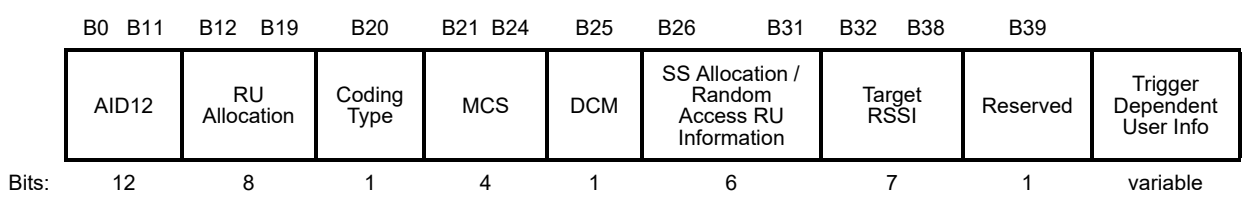


Figure 9-52g—User Info field

fields and UMRS Control field)). An AID12 subfield set to 4095 is reserved to indicate start of Padding field (see 27.5.3.2.2 (Padding for Trigger frame or frame containing UMRS Control field)).

When the value of the AID12 subfield is not 0 or 2045, then the RU Allocation subfield of the User Info field indicates the RU used by the HE TB PPDU of the STA identified by the AID12 subfield. The first bit, B12, is set to 0 to indicate that the allocated RU is located within the primary 80 MHz and is set to 1 to indicate that the allocated RU is located within the secondary 80 MHz. The mapping of the subsequent 7 bits, B19-B13, indices to the RU allocation is defined in Table 9-25h (The encoding of B19–B13 of the RU Allocation subfield).

Table 9-25h—The encoding of B19–B13 of the RU Allocation subfield

B19 – B13	Description	Number of entries
0–36	Possible 26-tone RU cases in 80 MHz	37
37–52	Possible 52-tone RU cases in 80 MHz	16
53–60	Possible 106-tone RU cases in 80 MHz	8
61–64	Possible 242-tone RU cases in 80 MHz	4
65–66	Possible 484-tone RU cases in 80 MHz	2
67	996-tone RU cases in 80 MHz	1
68	2×996-tone RU case	1
69–127	Reserved	59
Total		128

NOTE—These values are in binary form in PHY (for example, see Table 28-24 (RU Allocation subfield))

B12 is set to 0 for 20 MHz, 40 MHz and 80 MHz PPDUs, and is set to either 0 or 1 for 80+80 MHz and 160 MHz PPDUs. The mapping of subsequent 7 bits indices B19-B13 to RU index in each row depends on the BW subfield in Common Info field:

— For a 20 MHz PPDU, the mapping of B19-B13 to RU allocation follows the RU index in Table 28-6 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU) in increasing order.
  - The value 0 indicates 26-tone RU1 [−121: −96], the value 8 indicates 26-tone RU9 [96: 121], and the values 9–36 are not used.
  - The value 37 indicates 52-tone RU1 [−121: −70], the value 40 indicates 52-tone RU4 [70: 121], and the values 41–52 are not used.
  - The value 53 indicates 106-tone RU1 [−122: −17], the value 54 indicates 106-tone RU2 [17: 122], and the values 55–60 are not used.

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- The value 61 indicates 242-tone RU1 [–122: –2, 2:122], and the values 62–64 are not used.

— For a 40 MHz PPDU, the mapping of B19-B13 to RU allocation follows the RU index in Table 28-7 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU) in increasing order.

- The value 0 indicates 26-tone RU1 [–243: –218], the value 17 indicates 26-tone RU18 [218: 243], and the values 18–36 are not used.
- The value 37 indicates 52-tone RU1 [–243: –192], the value 44 indicates 52-tone RU8 [192: 243], and the values 45–52 are not used.
- A similar ordering is followed for 106-tone RU, 242-tone RU and 484-tone RU.

— For an 80 MHz, 160 MHz and 80+80 MHz PPDU, the mapping of B19-B13 to RU allocation follows the RU index in Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU) in increasing order.

- The value 0 indicates 26-tone RU1 [–499: –474], and the value 36 indicates 26-tone RU37 [474: 499].
- The value 37 indicates 52-tone RU1 [–499: –448], and the value 52 indicates 52-tone RU16 [448: 499].
- A similar ordering is followed for 106-tone RU, 242-tone RU, 484-tone RU and 996-tone RU. For a 160 MHz and 80+80 MHz PPDU, B19-B13 are 1000100 indicates 2×996-tone RU.

When the value of the AID12 field is 0 or 2045, then the RU Allocation subfield indicates the first RU of one or more contiguous random access RUs. If there are more than one random access RUs, the sizes of all random access RUs are the same and equal to the size of the first RU. Further all the subfields of the User Info field apply to all the random access RUs.

The Coding Type subfield of the User Info field indicates the code type of the HE TB PPDU that is the response to the Trigger frame. The Coding Type subfield is set to 0 to indicate BCC and set to 1 to indicate LDPC.

The MCS subfield of the User Info field indicates the MCS of the HE TB PPDU that is the response to the Trigger frame. The encoding of the MCS field is defined in 28.3.7 (HE modulation and coding schemes (HE-MCSs)).

The DCM subfield of the User Info field indicates dual carrier modulation of the HE TB PPDU that is the response to the Trigger frame. The DCM subfield is set to 1 to indicate that DCM is used the HE TB PPDU that is the response to the Trigger frame as defined in 28.3.11.15 (Dual carrier modulation). The DCM subfield is set to 0 to indicate that DCM is not used.

If the AID12 field is neither 0 nor 2045, then the SS Allocation/Random Access RU Information subfield of the User Info field indicates the spatial streams of the HE TB PPDU that is the response to the Trigger frame and the format is defined in Figure 9-52h (SS Allocation/Random Access RU Information subfield format (AID12 subfield is neither 0 nor 2045)).

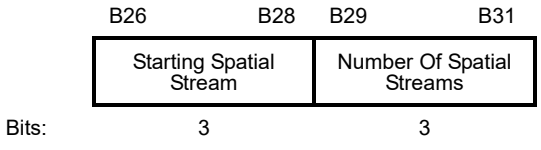


Figure 9-52h—SS Allocation/Random Access RU Information subfield format (AID12 subfield is neither 0 nor 2045)

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The Starting Spatial Stream subfield indicates the starting spatial stream, STARTING_SS_NUM, and is set to STARTING_SS_NUM – 1.

The Number Of Spatial Streams subfield indicates the number of spatial streams, NUM_SS and is set to NUM_SS – 1.

If the AID12 field is 0 or 2045, then the SS Allocation/Random Access RU Information subfield of the User Info field indicates the random access RU information and the format is defined in Figure 9-52h (SS Allocation/Random Access RU Information subfield format (AID12 subfield is neither 0 nor 2045)).

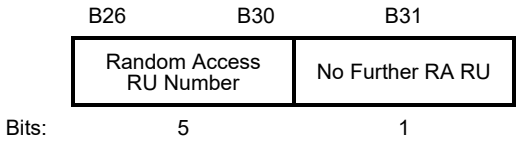


Figure 9-52i—SS Allocation/Random Access RU Information subfield format (AID12 subfield is 0 or 2045)

The Random Access RU Number subfield indicates the number of contiguous RUs allocated for UORA. The value of the Random Access RU Number subfield is equal to the number of contiguous random access RUs minus one. The starting spatial stream and the number of spatial streams of the HE TB PPDU transmitted on each random access RU are 1.

The No Further RA RU subfield is set to 1 to indicate that random access RUs are not allocated in subsequent Trigger frames that are sent before either the end of the current TWT SP or the end of the current TXOP in the case of no TWT SP.

The Target RSSI subfield of the User Info field indicates the target receive signal power averaged over the AP's antenna connectors for the HE TB PPDU that is the response to the Trigger frame. The resolution for the Target RSSI subfield in the User Info field is 1 dB. The Target RSSI subfield encoding is defined in Table 9-25i (Target RSSI subfield encoding).

Table 9-25i—Target RSSI subfield encoding

Target RSSI subfield	Description
0–90	Values 0 to 90 map to –110 dBm to –20 dBm
91–126	Reserved
127	Indicates to the STA to transmit an HE TB PPDU response at its maximum transmit power for the assigned MCS

The Trigger Dependent User Info subfield in the User Info field is optionally present based on the value of the Trigger Type field.

The Padding field is optionally present in a Trigger frame to extend the frame length to give the recipient STAs enough time to prepare a response SIFS after the frame is received. The Padding field of the Trigger frame, if present, is at least two octets in length and is set to all 1s. The start of the Padding field is identified

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by the value 4095 in the AID12 subfield of a User Info field that would otherwise be present. An AP can use any type of padding to satisfy the duration requirement (see 27.5.3.2.2 (Padding for Trigger frame or frame containing UMRS Control field)). An example of how to compute the length, $L_{PAD,MAC}$, of the Padding field (if present) to meet the duration requirements is given below.

For a non-HT PPDU, HT PPDU and VHT PPDU, the length of the Padding field (in octets)), which depends on the *MinTrigProcTime* (see 27.5.3.2.2 (Padding for Trigger frame or frame containing UMRS Control field), is given by Equation (9-0a).

$$L_{PAD,MAC} = \left\lceil \frac{N_{DBPS} m_{PAD}}{8} \right\rceil \quad (9\text{-}0a)$$

where

$$m_{PAD} = \begin{cases} 0, \text{ if } MinTrigProcTime \text{ is } 0\ \mu s \\ 2, \text{ if } MinTrigProcTime \text{ is } 8\ \mu s \\ 4, \text{ if } MinTrigProcTime \text{ is } 16\ \mu s \end{cases}$$

N_{DBPS} is defined in Table 28-13 (Tone allocation related constants for the Data field in a non-OFDMA HE PPDU)

For an HE PPDU, the length of the Padding field (in octets), which depends on the *MinTrigProcTime* (see 27.5.3.2.2 (Padding for Trigger frame or frame containing UMRS Control field), is given by Equation (9-0b).

$$L_{PAD,MAC} = \left\lceil \frac{N_{DBPS,SHORT} m_{PAD}}{8} \right\rceil \quad (9\text{-}0b)$$

where

$N_{DBPS,SHORT}$ is defined in 28.3.11.2 (Pre-FEC padding process)

9.3.1.23.1 Basic Trigger variant

The Trigger Dependent Common Info subfield is not present in the Basic Trigger frame. The Trigger Dependent User Info subfield of the Basic Trigger frame is defined in Figure 9-52j (Trigger Dependent User Info subfield for the Basic Trigger variant).

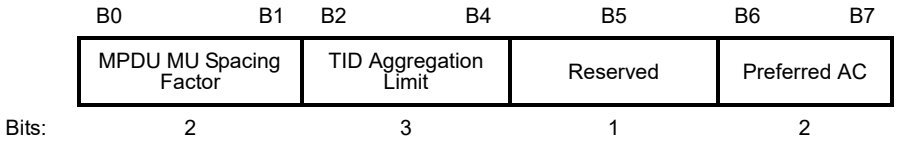


Figure 9-52j—Trigger Dependent User Info subfield for the Basic Trigger variant

The MPDU MU Spacing Factor subfield is used for calculating *MSF*, the value by which the minimum MPDU start spacing is multiplied (see 10.13.3 (Minimum MPDU Sstart Sspacing field rules)). *MSF* is equal to $2^{\text{MPDU MU Spacing Factor}}$.

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The TID Aggregation Limit subfield indicates the MPDUs allowed in an A-MPDU carried in the HE TB PPDU and the maximum number of TIDs that can be aggregated by the STA in the A-MPDU and is set as defined in 27.5.3.2.3 (Allowed settings of the Trigger frame fields and UMRS Control field).

The value in the TID Aggregation Limit subfield in Trigger frame is less than or equal to *MT* + 1, where *MT* is the value indicated in the Multi-TID Aggregation Support subfield in the HE MAC Capabilities Information field in the HE Capabilities element transmitted by the AP that is the intended receiver of the User Info field.

The Preferred AC subfield indicates the lowest AC that is recommended for aggregation of MPDUs in the A-MPDU contained in the HE TB PPDU sent as a response to the Trigger frame (see 9.3.1.23 (Trigger frame format)). The encoding of the Preferred AC subfield is shown in Table 9-25j (Preferred AC subfield encoding).

Table 9-25j—Preferred AC subfield encoding

Value	Description
3	AC_VO
2	AC_VI
1	AC_BE
0	AC_BK

9.3.1.23.2 Beamforming Report Poll (BRP) variant

The Trigger Dependent Common Info subfield is not present in the BRP Trigger frame. The Trigger Dependent User Info subfield of the BRP Trigger frame is defined in Figure 9-52k (Trigger Dependent User Info subfield for the Beamforming Report Poll variant).

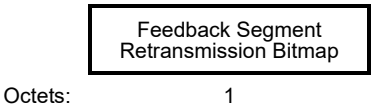


Figure 9-52k—Trigger Dependent User Info subfield for the Beamforming Report Poll variant

The Feedback Segment Retransmission Bitmap subfield indicates the requested feedback segments of an HE compressed beamforming report. If the bit in position *n* (*n* = 0 for LSB and *n* = 7 for MSB) is 1, then the feedback segment with the Remaining Feedback Segments subfield in the HE MIMO Control field equal to *n* is requested. If the bit in position *n* is 0, then the feedback segment with the Remaining Feedback Segments subfield in the HE MIMO Control field equal to n is not requested.

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9.3.1.23.3 MU-BAR variant

The Trigger Dependent Common Info subfield is not present in the MU-BAR Trigger frame. The Trigger Dependent User Info subfield for the MU-BAR Trigger frame is defined in Figure 9-52l (Trigger Dependent User Info subfield for the MU-BAR variant).

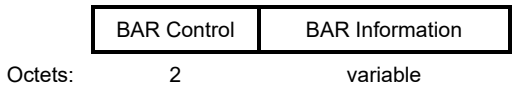


Figure 9-52l—Trigger Dependent User Info subfield for the MU-BAR variant

The BAR Control subfield is defined in 9.3.1.8 (BlockAckReq frame format) and indicates either a Compressed BlockAckReq variant or a Multi-TID BlockAckReq variant.

The BAR Information subfield is defined in 9.3.1.8 (BlockAckReq frame format).

9.3.1.23.4 MU-RTS variant

The Trigger Dependent Common Info subfield and Trigger Dependent User Info subfield are not present in the MU-RTS Trigger frame.

The RA field of the MU-RTS Trigger frame is set to the broadcast address.

The CS Required subfield in the Common Info field is set as described in 27.5.3.5 (UL MU CS mechanism).

The BW subfield in the Common Info field indicates the total PPDU bandwidth, and is defined in Table 9-25c (BW subfield encoding).

The Length, GI And LTF Type, MU-MIMO LTF Mode, Number Of HE-LTF Symbols, STBC, LDPC Extra Symbol Segment, AP TX Power, Packet Extension, Spatial Reuse, Doppler and HE-SIG-A Reserved subfields in the Common Info field are reserved.

The MCS, Coding Type, DCM, SS Allocation and Target RSSI fields in the User Info field are reserved.

The RU Allocation subfield in the User Info field addressed to the STA indicates whether the CTS frame is transmitted on the primary 20 MHz channel, primary 40 MHz channel, primary 80 MHz channel, 160 MHz channel, or 80+80 MHz channel.

B12 of the RU Allocation subfield is set to 0 to indicate primary 20 MHz channel, primary 40 MHz channel and primary 80 MHz channel. For 160 MHz and 80+80 MHz indication, B12 of the RU Allocation subfield is set to 1.

If the BW subfield indicates 20 MHz, then the primary 20 MHz channel is indicated by setting B19-B13 of the RU Allocation subfield to 61.

If the BW subfield indicates 40 MHz, then

— The primary 20 MHz channel is indicated by setting B19-B13 of the RU Allocation subfield to 61 when the primary 20 MHz channel is the lowest frequency 20 MHz channel and 62 when the primary 20 MHz channel is the second lowest frequency 20 MHz channel.

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— The primary 40 MHz channel is indicated by setting B19-B13 of the RU Allocation subfield to 65.

If the BW subfield indicates 80 MHz, 80+80 MHz or 160 MHz, then

— The primary 20 MHz channel is indicated by setting B19-B13 of the RU Allocation subfield to 61 when the primary 20 MHz channel is the lowest frequency 20 MHz channel in the primary 80MHz channel, 62 when the primary 20 MHz channel is the second lowest frequency 20 MHz channel in the primary 80MHz, 63 when the primary 20 MHz channel is the third lowest frequency 20 MHz channel in the primary 80MHz, and 64 when the primary 20 MHz channel is the fourth lowest frequency 20 MHz channel in the primary 80 MHz.

— The primary 40 MHz channel is indicated by setting B19-B13 of the RU Allocation subfield to 65 when the primary 40 MHz channel is the lowest frequency 40 MHz channel in the primary 80 MHz channel and 66 when the primary 40 MHz channel is the second lowest frequency 40 MHz channel in the primary 80 MHz channel.

— The primary 80 MHz channel is indicated by setting B19-B13 of the RU Allocation subfield to 67.

If the BW field indicates 80+80 MHz or 160 MHz, then the primary and secondary 80 MHz is indicated by setting B19-B13 of the RU Allocation subfield to 68.

9.3.1.23.5 Buffer Status Report Poll (BSRP) variant

The Trigger Dependent Common Info subfield and Trigger Dependent User Info subfield are not present in the BSRP Trigger frame.

9.3.1.23.6 GCR MU-BAR variant

The Trigger Dependent Common Info subfield of the GCR MU-BAR Trigger frame is defined in Figure 9-52m (Trigger Dependent Common Info subfield for the GCR MU-BAR variant). The Trigger Dependent User Info subfield is not present in the GCR MU-BAR Trigger frame.

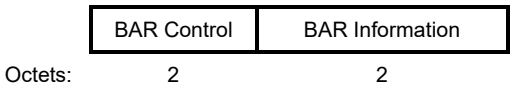


Figure 9-52m—Trigger Dependent Common Info subfield for the GCR MU-BAR variant

The BAR Control subfield is defined in 9.3.1.8 (BlockAckReq frame format) and indicates a GCR Block-AckReq variant.

The BAR Information subfield is defined in 9.3.1.8.6 (GCR BlockAckReq variant) except that the GCR Group Address field is not present.

9.3.1.23.7 Bandwidth Query Report Poll (BQRP) variant

The Trigger Dependent Common Info subfield and Trigger Dependent User Info subfield are not present in the BQRP Trigger frame.

9.3.1.23.8 NDP Feedback Report Poll variant

The NDP Feedback Report Poll Trigger frame format is defined in Figure 9-52c (Trigger frame).

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The RA field is set to the broadcast address.

The Common Info field of the NDP Feedback Report Poll Trigger frame is defined in Figure 9-52d (Common Info field).

The BW subfield indicates the bandwidth of the NDP feedback report response and is defined in Table 9-25c (BW subfield encoding).

The CS Required subfield of the NDP Feedback Report Poll Trigger frame may be set to 0.

The STBC, LDPC Extra Symbol Segment, Packet Extension, and Doppler subfields are reserved.

The Number of HE-LTFs subfield of the Common Info field indicates the number of HE-LTF symbols present in the NDP feedback report response and is set to 2 for 2 HE-LTF symbols.

The GI and LTF Type subfield of the Common Info field is set to 2.

The Trigger Dependent Common Info subfield is not present.

The User Info field for NDP Feedback Report Poll Trigger frame is defined in Figure 9-52n (User Info field for the NDP Feedback Report Poll variant).

	Starting AID	Reserved	Feedback Type	Reserved	Target RSSI	Multiplexing Flag
Bits:	12	9	4	7	7	1

Figure 9-52n—User Info field for the NDP Feedback Report Poll variant

The Feedback Type subfield encoding is defined in Table 9-25k (Feedback Type subfield encoding).

Table 9-25k—Feedback Type subfield encoding

Value	Description
0	Resource request
1-15	Reserved

The scheduled HE non-AP STAs are identified by a range of AIDs. The Starting AID field defines the first AID of the range of AIDs that are scheduled to respond to the NDP Feedback Report Poll Trigger frame.

The Target RSSI subfield indicates the target received signal power of the NDP feedback report response for all scheduled STAs. The resolution for the Target RSSI subfield is 1 dB. The Target RSSI subfield encoding is defined in Table 9-25i (Target RSSI subfield encoding).

The total number of STAs, N_{STA}, that are scheduled to respond to the NDP Feedback Report Poll Trigger frame is calculated using Equation (9-ax1).

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$$N_{STA} = 18 \times 2^{BW} \times (Multiplexing\ Flag) \quad \text{(9-ax1)}$$

where *BW* is the value indicated in the BW subfield of the NDP Feedback Report Poll Trigger frame, *Multiplexing Flag* is the value indicated in the Multiplexing Flag subfield of the NDP Feedback Report Poll Trigger frame.

The Multiplexing Flag subfield indicates the number of STAs that are multiplexed with P-matrix codes on the same set of tones in the same RU, and is encoded as the number of STAs minus 1.

9.3.3 Management frames

9.3.3.3 Beacon frame format

Editor's Note: Order: 11ai adds 64-71, 11ah adds none, 11aq adds 72-73, 11ak adds 74, 11aj adds none.

Insert the following new rows into Table 9-27 (Beacon frame body):

Table 9-27—Beacon frame body

Order	Information	Notes
75	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented is true; otherwise it is not present.
76	HE Operation	The HE Operation element is present when dot11HEOptionImplemented is true; otherwise it is not present.
77	TWT	The TWT element is optionally present when dot11TWTOptionActivated is true; otherwise it is not present.
78	UORA Parameter Set	The UORA Parameter Set element is optionally present when dot11OFDMARandomAccessOptionImlemented is true; otherwise it is not present.
79	BSS Color Change Announcement	The BSS Color Change Announcement element is optionally present when dot11HEOptionImplemented is true; otherwise it is not present.
80	Spatial Reuse Parameter Set	The Spatial Reuse Parameter Set element is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise it is not present.
81	MU EDCA Parameter Set	The MU EDCA Parameter element is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise it is not present.
82	ESS Report	The ESS Report element is optionally present when dot11HEOptionImplemented is true; otherwise it is not present.

9.3.3.6 Association Request frame format

Editor's Note: Order: 11ai adds 24-28, 11ah adds 29-38, 11ak adds 39-40, 11aj adds 41-42

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Insert the following new row into Table 9-29 (Association Request frame body):

Table 9-29—Association Request frame body

Order	Information	Notes
43	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented is true; otherwise it is not present.

9.3.3.7 Association Response frame format

Editor's Note: Order: 11ai adds 31-36, 11ah adds 37-49, 11aq adds none, 11ak adds 50-51, 11aj adds 50-52

Change Table 9-30 (Association Response frame body) as follows maintaining numeric order:

Table 9-30—Association Response frame body

Order	Information	Notes
38	TWT	The TWT element is present if dot11TWTOptionActivated is true and the TWT element is present in the Association Request frame that elicited this Association Response frame. The TWT element is optionally present if dot11TWTOptionActivated is true and the TWT Requester Support field in the HE Capabilities element in the Association Request frame that elicited this Association Response frame is 1. Otherwise, the TWT element is not present.
55	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented is true; otherwise it is not present.
56	HE Operation	The HE Operation element is present when dot11HEOptionImplemented is true; otherwise it is not present.
57	BSS Color Change Announcement	The BSS Color Change Announcement element is optionally present when dot11HEOptionImplemented is true; otherwise it is not pre-sent.
58	Spatial Reuse Parameter Set	The Spatial Reuse Parameter Set element is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise it is not present.
59	MU EDCA Parameter Set	The MU EDCA Parameter Set element is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, it is not present.
60	UORA Parameter Set	The UORA Parameter Set element is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, it is not present.
61	ESS Report	The ESS Report element is optionally present when dot11HEOptionImplemented is true; otherwise it is not present.

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9.3.3.8 Reassociation Request frame format

Editor's Note: Order: 11ai adds 29-33, 11ah adds 34-43, 11aq adds none, 11ak adds 44-45, 11aj adds 46-47

Insert the following row in Table 9-31 (Reassociation Request frame body):

Table 9-31—Reassociation Request frame body

Order	Information	Notes
48	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented is true; otherwise it is not present.

9.3.3.9 Reassociation Response frame format

Editor's Note: Order: 11ai adds 35-40, 11ah adds 41-52, 11aq adds none, 11ak adds 53-54, 11aj adds 54-56

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Change Table 9-32 (Reassociation Response frame body) as follows maintaining numeric order:

Table 9-32—Reassociation Response frame body

Order	Information	Notes
42	TWT	The TWT element is present if dot11TWTOptionActivated is true and the TWT element is present in the Reassociation Request frame that elicited this Reassociation Response frame. The TWT element is optionally present if dot11TWTOptionActivated is true and the TWT Requester Support field in the HE Capabilities in the Reassociation Request frame that elicited this Reassociation Response frame is 1. Otherwise, the TWT element is not present.
58	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented is true; otherwise it is not present.
59	HE Operation	The HE Operation element is present when dot11HEOptionImplemented is true; otherwise it is not present.
60	BSS Color Change Announcement	The BSS Color Change Announcement element is optionally present when dot11HEOptionImplemented is true; otherwise it is not present.
61	Spatial Reuse Parameter Set	The Spatial Reuse Parameter Set element is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise it is not present.
62	MU EDCA Parameter Set	The MU EDCA Parameter Set element is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, it is not present.
63	UORA Parameter Set	The UORA Parameter Set element is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, it is not present.
64	ESS Report	The ESS Report element is optionally present when dot11HEOptionImplemented is true; otherwise it is not present.

9.3.3.10 Probe Request frame format

Editor's Note: Order: 11ai adds 20-21, 11ah adds 22-27, 11aq adds none, 11ak adds 28, 11aj adds 31-33

Insert the following new row into Table 9-33 (Probe Request frame body):

Table 9-33—Probe Request frame body

Order	Information	Notes
32	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented is true; otherwise it is not present.

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9.3.3.11 Probe Response frame format

Editor's Note: Order: 11ai adds 70-73, 11ah adds 74-84, 11aq adds 85-86, 11ak adds 87, 11aj adds 88-91

Insert the following new rows into Table 9-34 (Probe Response frame body):

Table 9-34—Probe Response frame body

Order	Information	Notes
92	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented is true; otherwise it is not present.
93	HE Operation	The HE Operation element is present when dot11HEOptionImplemented is true; otherwise it is not present.
94	TWT	The TWT element is optionally present within broadcast Probe Response frames when dot11TWTOptionActivated, dot11HEOptionImplemented and dot11FILSOmitReplicateProbeResponses are true; otherwise it is not present.
95	UORA Parameter Set	The UORA Parameter Set element is optionally present when dot11OFDMARandomAccessOptionImlemented is true; otherwise it is not present.
96	BSS Color Change Announcement	The BSS Color Change Announcement element is optionally present when dot11HEOptionImplemented is true; otherwise it is not present.
97	Spatial Reuse Parameter Set	The Spatial Reuse Parameter Set element is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise it is not present.
98	MU EDCA Parameter Set	The MU EDCA Parameter Set element is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, it is not present.
99	ESS Report	The ESS Report element is optionally present when dot11HEOptionImplemented is true; otherwise it is not present.

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9.4 Management and Extension frame body components

9.4.1 Fields that are not elements

9.4.1.11 Action field

Insert the following rows into Table 9-47 in numerical order and update the Reserved row:

Table 9-47—Category values

Code	Meaning	See subclause	Robust	Group addressed privacy
30	HE	9.6.28 (HE Action frame details)	No	No
31	Protected HE	9.6.29 (Protected HE Action frame details)	Yes	No

9.4.1.17 QoS Info field

Change Figure 9-82 (QoS Info field when sent by an AP) as follows:

	B0 – B3	B4	B5	B6	B7
	EDCA Parameter Set Update Count	Q-Ack	Queue Request	TXOP Request	~~Reserved~~ More Data Ack
Bits:	4	1	1	1	1

Figure 9-82—QoS Info field when sent by an AP

Change the last paragraph of this sublcause as follows:

Non-AP STAs set the More Data Ack subfield to 1 to indicate that they can process (Ack frames with the More Data bit in the Frame Control field equal to 1 and remain in the awake state. Non-AP STAs set the More Data Ack subfield to 0 otherwise. An HE AP sets the More Data Ack subfield to 1 to indicate that it can generate individually addressed Ack, BlockAck, and Multi-STA BlockAck frames with the More Data bit in the Frame Control field equal to 1; otherwise the AP sets the More Data Ack subfield to 0. For non-HE APs, the More Data Ack subfield is reserved. An HE TDLS peer STA uses the More Data Ack subfield to indicate support for both processing and generating these control response frames.

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9.4.1.53 Operating Mode field

Change Table 9-74 as follows:

Table 9-48—Subfield values of the Operating Mode field

Subfield	Description
Channel Width	If the Rx NSS Type subfield is 0, indicates the supported channel width: In a VHT STA, see Table 9-75 (Setting of the Channel Width subfield and 160/80+80 BW subfield at a VHT STA transmitting the Operating Mode field) In a TVHT STA: Set to 0 for TVHT_W Set to 1 for TVHT_2W and TVHT_W+W Set to 2 for TVHT_4W and TVHT_2W+2W The value of 3 is reserved. Reserved if the Rx NSS Type subfield is 1.
160/80+80 BW	This subfield, combined with the Channel Width subfield, the Supported Channel Width Set subfield and the Supported VHT-MCS and NSS Set subfield indicates whether 80+80 MHz and 160 MHz operation is supported. In a VHT STA, see Table 9-75 (Setting of the Channel Width subfield and 160/80+80 BW subfield at a VHT STA transmitting the Operating Mode field). In a TVHT STA, this field is reserved. In a STA with dot11VHTExtendedNSSBWCapable either equal to false or not present, this field is set to 0.
No LDPC	Set to 1 to indicate that the STA transmitting this field prefers not to receive LDPC-encoded PPDUs; set to 0 otherwise.

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Table 9-48—Subfield values of the Operating Mode field

Rx NSS	~~If~~ When the STA that transmits the Operating Control field (STA1) and the receiver of the Operating Control field (STA2) are not both HE STAs, if the Rx NSS Type subfield is 0, the value of this field, combined with other information described in 9.4.2.158.3 (Supported VHT-MCS and NSS Set field), indicates the maximum number of spatial streams that ~~the STA~~ STA1 can receive. When the STA that transmits the Operating Control field (STA1) and the receiver of the Operating Control field (STA2) are both HE STAs, if the Rx NSS Type subfield is 0, then the following apply: — The value of this field, combined with other information described in 9.4.2.158.3 (Supported VHT-MCS and NSS Set field), indicates the maximum number of spatial streams that the HE STA can receive in a VHT PPDU — The value of this field, combined with other information described in 9.4.2.237.4 (Supported HE-MCS and NSS Set field), indicates the maximum number of spatial streams that STA1 can receive in an HE PPDU. If the Rx NSS Type subfield is 1, the value of this field, indicates the maximum number of spatial streams that the STA can receive as a beamformee in an SU PPDU using a beamforming steering matrix derived from a VHT Compressed Beamforming report with Feedback Type subfield indicating MU in the corresponding VHT Compressed Beamforming frame sent by the STA. Set to 0 for $N_{SS} = 1$ Set to 1 for $N_{SS} = 2$ … Set to 7 for $N_{SS} = 8$ NOTE—In a STA with dot11VHTExtendedNSSBWCapable equal to true, NSS might be further modified for VHT PPDUs per Table 9-75 (Setting of the Channel Width subfield and 160/80+80 BW subfield at a VHT STA transmitting the Operating Mode field). In a HE STA with dot11VHTExtendedNSSBWCapable equal to true, NSS might be further modified for HE PPDUs per Equation (9-ax2).
Rx NSS Type	Set to 0 to indicate that the Rx NSS subfield carries the maximum number of spatial streams that the STA can receive in any PPDU. Set to 1 to indicate that the Rx NSS subfield carries the maximum number of spatial streams that the STA can receive as a beamformee in an SU PPDU using a beamforming steering matrix derived from a VHT Compressed Beamforming report with the Feedback Type subfield indicating MU in the corresponding VHT Compressed Beamforming frame sent by the STA. NOTE—An AP always sets this field to 0.

Insert the following at the end of 9.4.1.53:

The Rx NSS support for a given HE-MCS as a function of the received HE PPDU bandwidth BW at an HE STA transmitting an Operating Mode field is defined as

$$\text{floor}\,(Rx\text{-}NSS\text{-}from\text{-}OMF \times (Max\text{-}HE\text{-}NSS\text{-}at\text{-}BW \,/\, Max\text{-}HE\text{-}NSS\text{-}at\text{-}80)) \quad \text{(9-ax2)}$$

where

Rx-NSS-from-OMF is Rx NSS from the Operating Mode field transmitted by the STA

Max-HE-NSS-at-BW is the maximum HE NSS among all HE-MCS at *BW* MHz from the Supported HE-MCS And NSS Set field transmitted by the STA

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Max-HE-NSS-at-80 is the maximum HE NSS among all HE-MCS at 80 MHz from the Supported HE-MCS and NSS Set field transmitted by the STA

NOTE—For operating mode between two HE STAs, the Rx NSS subfield indicates the maximum number of spatial streams at BWs that is the same as or narrower than 80 MHz.

9.4.1.60 TWT Information field

Change Figure 9-121c (TWT Information field format) as follows:

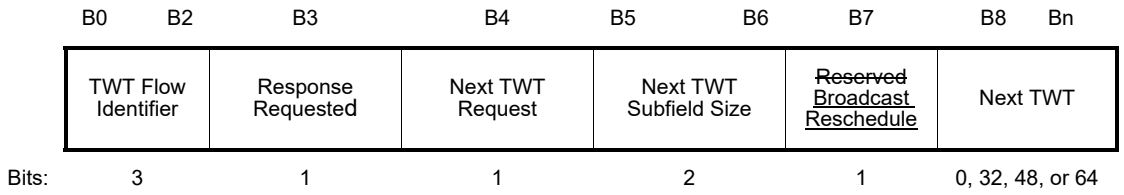


Figure 9-121c—TWT Information field format

Insert the following before the last paragraph:

The Broadcast Reschedule subfield is set to 1 by an HE STA to indicate that the TWT Information frame reschedules Broadcast TWTs as defined in 27.7.4 (Use of TWT Information frames). Otherwise, it is set to 0.

Insert the following subclauses after 9.4.1.61:

9.4.1.62 HE MIMO Control field

The HE MIMO Control field is included in every HE Compressed Beamforming frame (see 9.4.1.63 (HE Compressed Beamforming Report field)). The HE MIMO Control field is defined in Figure 9-121d (HE MIMO Control field).

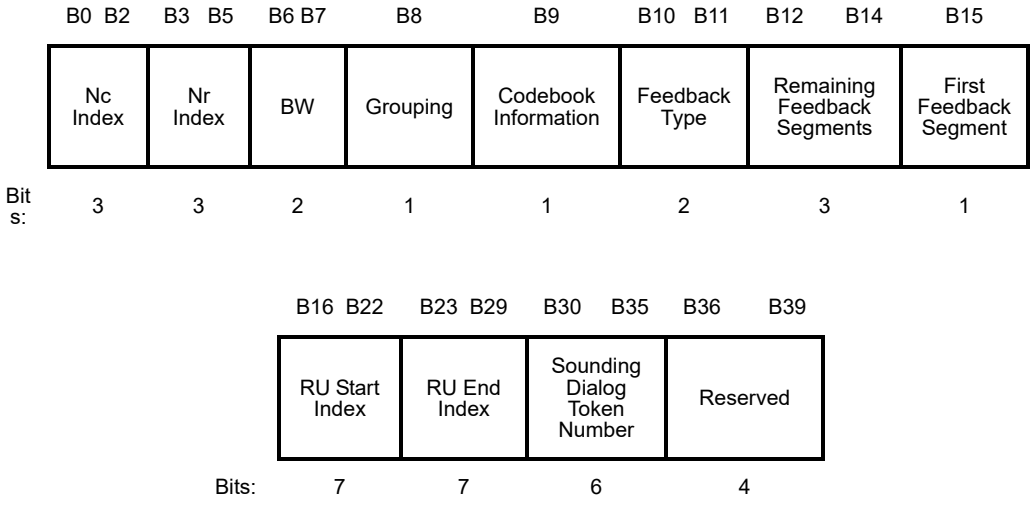


Figure 9-121d—HE MIMO Control field

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The subfields of the HE MIMO Control field are defined in Table 9-76a (HE MIMO Control field encoding).

Table 9-76a—HE MIMO Control field encoding

Subfield	Description
Nc Index	Indicates the number of columns, *Nc*, in the compressed beamforming feedback matrix minus 1: Set to 0 for *Nc* = 1 Set to 1 for *Nc* = 2 … Set to 7 for *Nc* = 8
Nr Index	Indicates the number of rows, *Nr*, in the compressed beamforming feedback matrix minus 1: Set to 0 for *Nr* = 1 Set to 1 for *Nr* = 2 … Set to 7 for *Nr* = 8
BW	Indicates the channel width used to determine the starting and ending subcarrier indexes when interpreting the RU Start Index and RU End Index subfields. Set to 0 for 20 MHz Set to 1 for 40 MHz Set to 2 for 80 MHz Set to 3 for 160 MHz and 80+80 MHz
Grouping	Indicates the subcarrier grouping, *Ng*, used for the compressed beamforming feedback matrix: Set to 0 for *Ng* = 4 Set to 1 for *Ng* = 16
Codebook Information	Indicates the size of codebook entries: If the Feedback Type subfield indicates SU: Set to 0 for 2 bits for ψ, 4 bits for ϕ Set to 1 for 4 bits for ψ, 6 bits for ϕ If the Feedback Type subfield indicates MU: Set to 0 for 5 bits for ψ, 7 bits for ϕ Set to 1 for 7 bits for ψ, 9 bits for ϕ NOTE—The codebook size for MU Feedback with *Ng* = 16 is limited to (ϕ, ψ) = {9, 7}
Feedback Type	Indicates the feedback type: Set to 0 for SU Set to 1 for MU Set to 2 for CQI feedback 3 is reserved
Remaining Feedback Segments	Indicates the number of remaining feedback segments for the associated HE Compressed Beamforming And CQI frame: Set to 0 for the last feedback segment of a segmented report or the only feedback segment of an unsegmented report. Set to a value between 1 and 6 for a feedback segment that is neither the first nor the last of a segmented report. Set to a value between 1 and 7 for a feedback segment that is not the last feedback segment of a segmented report. In a retransmitted feedback segment, the subfield is set to the same value associated with the feedback segment in the original transmission.

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Table 9-76a—HE MIMO Control field encoding *(continued)*

First Feedback Segment	Set to 1 for the first feedback segment of a segmented report or the only feedback segment of an unsegmented report. Set to 0 if not the first feedback segment or if the HE Compressed Beamforming Report field and HE MU Exclusive Beamforming Report field are not present in the frame. In a retransmitted feedback segment, the subfield is set to the same value associated with the feedback segment in the original transmission.
RU Start Index	The starting RU index indicates the first 26-tone RU for which the HE beamformer is requesting feedback.
RU End Index	The ending RU index indicates the last 26-tone RU for which the HE beamformer is requesting feedback.
Sounding Dialog Token Number	The ending RU index indicates the last RU26 for which the HE beamformer is requesting feedback.

In an HE Compressed Beamforming And CQI frame not carrying all or part of an HE compressed beamforming report, the Nc Index, Nr Index, Channel Width, Grouping, Codebook Information, Feedback Type and Sounding Dialog Token Number subfields are reserved, the First Feedback Segment subfield is set to 0 and the Remaining Feedback Segments subfield is set to 7.

9.4.1.63 HE Compressed Beamforming Report field

The HE Compressed Beamforming Report field is used in the HE Compressed Beamforming And CQI frame (see 9.6.28.2 (HE Compressed Beamforming And CQI frame format)) to carry average SNR of each space-time stream and compressed beamforming feedback matrices V for use by a transmit beamformer to determine steering matrices Q, as described in 10.32.3 (Explicit feedback beamforming) and 19.3.12.3 (Explicit feedback beamforming).

The size of the HE Compressed Beamforming Report field depends on the values in the HE MIMO Control field. The HE Compressed Beamforming Report field contains HE Compressed Beamforming Report information or successive (possibly zero-length) portions thereof in the case of segmented HE compressed beamforming and CQI feedback (see 27.6 (HE sounding protocol)). HE Compressed Beamforming Report information is included in the HE compressed beamforming and CQI feedback if an SU feedback type or an MU feedback type is indicated in the Feedback Type field in the HE MIMO Control field.

The HE Compressed Beamforming Report information contains the channel matrix elements indexed, first, by matrix angles in order shown in Table 9-67 (Order of angles in the Compressed Beamforming Feedback Matrix subfield), and second, by data and pilot subcarrier index from lowest frequency to highest frequency. An explanation of how these angles are generated from the beamforming feedback matrix V is given in 19.3.12.3.6 (Compressed beamforming feedback matrix), where Nc is the number of columns in a compressed beamforming feedback matrix determined by the Nc Index subfield of the HE MIMO Control field, and Nr is the number of rows in a compressed beamforming feedback matrix determined by the Nr Index subfield of the HE MIMO Control field.

The beamforming feedback matrix V is formed by the beamformee as follows. The beamformer transmits an NDP with $N_{STS,NDP}$ space-time streams, where $N_{STS,NDP}$ takes a value between 2 and 8. Based on this NDP, the beamformee estimates the $N_{RX,BFEE} \times N_{STS,NDP}$ channel, and based on that channel it determines a $Nr \times Nc$ orthogonal matrix V, where Nr and Nc satisfy Equation (9-1).$N_{RX,BFEE}$ is the number of receiver chains used to receive the NDP at the beamformee.

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Further restrictions on *Nc* are described in 28.2 (HE PHY service interface). The angles are quantized as defined in Table 9-68 (Quantization of angles).

The HE Compressed Beamforming Report information has the structure and order defined in Table 9-76b (HE Compressed Beamforming Report information).

Table 9-76b—HE Compressed Beamforming Report information

Field	Size (bits)	Meaning
Average SNR of Space-Time Stream 1	8	Signal-to-noise ratio at the beamformee for space-time stream 1 averaged over all data subcarriers. See Table 9-71 (Average SNR of Space-Time Stream i subfield).
...		...
Average SNR of Space-Time Stream Nc	8	Signal-to-noise ratio at the beamformee for space-time stream Nc averaged over all data subcarriers. See Table 9-71 (Average SNR of Space-Time Stream i subfield).
Compressed Beamforming Feedback Matrix *V* for subcarrier $k = scidx(0)$	$Na \times (b_\psi + b_\phi)/2$	Compressed beamforming feedback matrix defined in Table 9-67 (Order of angles in the Compressed Beamforming Feedback Matrix subfield).
Compressed Beamforming Feedback Matrix *V* for subcarrier $k = scidx(1)$	$Na \times (b_\psi + b_\phi)/2$	Compressed beamforming feedback matrix defined in Table 9-67 (Order of angles in the Compressed Beamforming Feedback Matrix subfield).
Compressed Beamforming Feedback Matrix *V* for subcarrier $k = scidx(2)$	$Na \times (b_\psi + b_\phi)/2$	Compressed beamforming feedback matrix defined in Table 9-67 (Order of angles in the Compressed Beamforming Feedback Matrix subfield).
...		...
Compressed Beamforming Feedback Matrix *V* for subcarrier $k = scidx(Ns - 1)$	$Na \times (b_\psi + b_\phi)/2$	Compressed beamforming feedback matrix defined in Table 9-67 (Order of angles in the Compressed Beamforming Feedback Matrix subfield).

In Table 9-76b (HE Compressed Beamforming Report information), *Ns* is the number of subcarriers for which the Compressed Beamforming Feedback Matrix subfield is sent back to the beamformer. A beamformee may choose to reduce Ns by using a method referred to as grouping, in which only a single compressed beamforming feedback matrix is reported for each group of *Ng* adjacent subcarriers. For HE Compressed Beamforming Report, *Ns* is a function of the RU Start Index, RU End Index and Grouping subfields in the HE MIMO Control field (see 9.4.1.62 (HE MIMO Control field)). Subcarriers *scidx(0)* and *scidx(Ns − 1)* represent the S (Start)-tone corresponding to the RU Start Index and E (End)-tone corresponding to the RU End Index, respectively.

For 40 MHz and 80 MHz, when the aforementioned S-tone and E-tone indices lie on the same side of DC, $scidx(i) = scidx(i - 1) + Ng$, where $1 \le i \le Ns - 2$. However, when the S-tone and E-tone indices lie on different sides of DC, the following relationships hold separately for the two sides of DC.

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For the left of DC, $scidx(i) = scidx(i-1) + Ng$, where $1 \le i \le L$ and $scidx(L) = -4$.

For the right of DC, $scidx(i) = scidx(i-1) + Ng$, where $L+2 \le i \le Ns-2$ and $scidx(L+1) = 4$.

The S-tone and E-tone corresponding to the possible RU indices for 20 MHz, 40 MHz, and 80 MHz channels are listed in Table 9-76c (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 4) for $Ng = 4$ and Table 9-76d (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 16) for $Ng = 16$. For 160 MHz, to determine the S-tone and E-tone, RUs 37 to 73 occupying the higher 80 MHz use the same entries in Table 9-76c (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 4) and Table 9-76d (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 16) as RUs 0 to 36 occupying the lower 80 MHz. For 20 MHz, $scidx(i)$, where $1 \le i \le Ns-2$, includes all subcarrier indices between the S-tone and the E-tone subcarrier indices described in Table 9-76e (Feedback subcarrier indices for 20 MHz bandwidth for Ng = 4 and Ng = 16) for $Ng = 4$ and $Ng = 16$.

Table 9-76c—Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for *Ng* = 4

80 MHz 26-tone RU Index	80 MHz (S, E) feedback tone	40 MHz 26-tone RU Index	40 MHz (S, E) feedback tone	20 MHz 26-tone RU Index	20 MHz (S, E) feedback tone
0	–500, –472	0	= (S, E) for 80 MHz + 256		
1	–476, –448	1			
2	–448, –420	2			
3	–420, –392	3			
4	–392, –364	4			
5	–368, –340	5			
6	–340, –312	6			
7	–312, –284	7			
8	–288, –260	8			
9	–260, –232				
10	–232, –204				
11	–204, –176				
12	–180, –152				
13	–152, –124				
14	–124, –96			0	–122, –96
15	–100, –72			1	= (S, E) for 80 MHz + 4
16	–72, –44			2	

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Table 9-76c—Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for *Ng* = 4 *(continued)*

80 MHz 26-tone RU Index	80 MHz (S, E) feedback tone	40 MHz 26-tone RU Index	40 MHz (S, E) feedback tone	20 MHz 26-tone RU Index	20 MHz (S, E) feedback tone
17	–44, –16			3	= (S, E) for 80 MHz
18	–16, 16			4	
19	16, 44			5	
20	44, 72			6	= (S, E) for 80 MHz – 4
21	72, 100			7	
22	96, 124			8	96, 122
23	124, 152				
24	152, 180				
25	176, 204				
26	204, 232				
27	232, 260				
28	260, 288	9	= (S, E) for 80 MHz – 256		
29	284, 312	10			
30	312, 340	11			
31	340, 368	12			
32	364, 392	13			
33	392, 420	14			
34	420, 448	15			
35	448, 476	16			
36	472, 500	17			

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Table 9-76d—Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for *Ng* = 16

80 MHz 26-tone RU index	80 MHz (S, E) feedback tone	40 MHz 26-tone RU index	40 MHz (S, E) feedback tone	20 MHz 26-tone RU index	20 MHz (S, E) feedback tone
0	–500, –468	0	= (S, E) for 80 MHz + 256		
1	–484, –436	1			
2	–452, –420	2			
3	–420, –388	3			
4	–404, –356	4			
5	–372, –340	5			
6	–340, –308	6			
7	–324, –276	7			
8	–292, –260	8			
9	–260, –228				
10	–244, –196				
11	–212, –164				
12	–180, –148				
13	–164, –116				
14	–132, –84			0	–122, –84
15	–100, –68			1	= (S, E) for 80 MHz + 4
16	–84, –36			2	
17	–52, –4			3	= (S, E) for 80 MHz
18	–20, 20			4	
19	4, 52			5	
20	36, 84			6	= (S, E) for 80 MHz – 4
21	68, 100			7	
22	84, 132			8	84, 122
23	116, 164				
24	148, 180				
25	164, 212				

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Table 9-76d—Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for *Ng* = 16 *(continued)*

80 MHz 26-tone RU index	80 MHz (S, E) feedback tone	40 MHz 26-tone RU index	40 MHz (S, E) feedback tone	20 MHz 26-tone RU index	20 MHz (S, E) feedback tone
26	196, 244				
27	228, 260				
28	260, 292	9	= (S, E) for 80 MHz – 256		
29	276, 324	10			
30	308, 340	11			
31	340, 372	12			
32	356, 404	13			
33	388, 420	14			
34	420, 452	15			
35	436, 484	16			
36	468, 500	17			

Table 9-76e—Feedback subcarrier indices for 20 MHz bandwidth for *Ng* = 4 and *Ng* = 16

Ng	Subcarrier indices
4	–122, –120, –116, –112, –108, –104, –100, –96, –92, –88, –84, –80, –76, –72, –68, –64, –60, –56, –52, –48, –44, –40, –36, –32, –28, –24, –20, –16, –12, –8, –4, –2, 2, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64, 68, 72, 76, 80, 84, 88, 92, 96, 100, 104, 108, 112, 116, 120, 122
16	–122, –116, –100, –84, –68, –52, –36, –20, –4, –2, 2, 4, 20, 36, 52, 68, 84, 100, 116, 122

The Average SNR of Space-Time Stream *i* subfield in Table 9-76b (HE Compressed Beamforming Report information) is an 8-bit twos complement integer defined in Table 9-71 (Average SNR of Space-Time Stream i subfield).

The $AvgSNR_i$ in Table 9-71 (Average SNR of Space-Time Stream i subfield) is found by computing the SNR per subcarrier in decibels for the subcarriers identified in Table 9-76c (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 4) for *Ng* = 4 and Table 9-76d (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 16) for *Ng* = 16, and then computing the arithmetic mean of those values. Each SNR value per subcarrier in stream *i* (before being averaged) corresponds to the SNR associated with column *i* of the beamforming feedback matrix *V* determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies all columns of the matrix *V*.

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An HE beamformee may support *Ng* = 16 in the HE Compressed Beamforming Report field for both SU and MU feedback types. A beamformer shall not request *Ng* = 16 for SU or MU feedback in an HE NDP Announcement frame unless the beamformee indicates support in the Ng = 16 For SU subfield or Ng = 16 For MU subfield, respectively, in the HE PHY Capabilities Information field of the HE Capabilities element it transmits (see 9.4.2.237 (HE Capabilities element)).

An HE beamformee may support a codebook size (ϕ, ψ) = {4, 2} in the HE Compressed Beamforming Report field for SU feedback type. A beamformer shall not request codebook size (ϕ, ψ) = {4, 2} in an HE NDP Announcement frame unless the beamformee indicates support in the Codebook Size (ϕ, ψ) = {4, 2} SU Feedback subfield in the HE PHY Capabilities Information field in the HE Capabilities element it transmits (see 9.4.2.237 (HE Capabilities element)).

An HE beamformee may support a codebook size (ϕ, ψ) = {7, 5} in the HE Compressed Beamforming Report field for MU feedback type. A beamformer shall not request the codebook size (ϕ, ψ) = {7, 5} in an HE NDP Announcement frame unless the beamformee indicates support for the Codebook Size (ϕ, ψ) = {7, 5} MU Feedback subfield in the HE PHY Capabilities Information field in the HE Capabilities element it transmits (see 9.4.2.237 (HE Capabilities element)).

9.4.1.64 HE MU Exclusive Beamforming Report field

The HE MU Exclusive Beamforming Report field is used by the HE Compressed Beamforming And CQI frame (see 9.6.28.2 (HE Compressed Beamforming And CQI frame format)) to carry explicit feedback in the form of delta SNRs. The information in the HE Compressed Beamforming Report field and the HE MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine the steering matrices *Q*, as described in 28.3.3.9 (DL MU-MIMO).

The size of the HE MU Exclusive Beamforming Report field depends on the values in the HE MIMO Control field. The HE MU Exclusive Beamforming Report field contains HE MU Exclusive Beamforming Report information or successive (possibly zero-length) portions thereof in the case of segmented HE compressed beamforming and CQI feedback (see 27.6.4 (Rules for generating segmented feedback)). HE Compressed Beamforming Report information and HE MU Exclusive Beamforming Report information are included in the HE compressed beamforming and CQI feedback if the Feedback Type subfield in the HE MIMO Control field indicates SU or MU.

The HE MU Exclusive Beamforming Report information consists of Delta SNR subfields for each of the space-time streams, 1 to *Nc*, of a subset of subcarriers typically spaced *Ng* apart, where *Ng* is signaled in the Grouping subfield of the HE MIMO Control field. The subset of subcarriers start from the lowest frequency subcarrier and continue to the highest frequency subcarrier. The subcarrier locations of the feedback for each Delta SNR subfield are identical to the subcarrier locations for the compressed beamforming feedback matrix *V*.

No padding is present between $\Delta SNR_{k,i}$, in the HE MU Exclusive Beamforming Report field, even if they correspond to different subcarriers. The subset of subcarriers included is determined by the values of the RU Start Index, RU End Index, and Grouping subfields of the HE MIMO Control field. For each subcarrier included, the deviation in dB of the SNR of that subcarrier for each column of *V* relative to the average SNR of the corresponding space-time stream is computed using Equation (9-2). In Equation (9-2), *k* is the subcarrier index in the range scidx(0), …, scidx(*Ns* − 1).

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The HE MU Exclusive Beamforming Report information has the structure and order defined in Table 9-76f (HE MU Exclusive Beamforming Report information).

Table 9-76f—HE MU Exclusive Beamforming Report information

Field	Size (bits)	Meaning
Delta SNR for space-time stream 1 for subcarrier $k = scidx(0)$	4	$\Delta SNR_{scidx(0),1}$ as defined in Equation (9-2).
...		...
Delta SNR for space-time stream Nc for subcarrier $k = scidx(0)$	4	$\Delta SNR_{scidx(0),Nc}$ as defined in Equation (9-2).
Delta SNR for space-time stream 1 for subcarrier $k = scidx(1)$	4	$\Delta SNR_{scidx(1),1}$ as defined in Equation (9-2).
...		...
Delta SNR for space-time stream Nc for subcarrier $k = scidx(1)$	4	$\Delta SNR_{scidx(1),Nc}$ as defined in Equation (9-2).
...		...
Delta SNR for space-time stream 1 for subcarrier $k = scidx(Ns - 1)$	4	$\Delta SNR_{scidx(Ns-1),1}$ as defined in Equation (9-2).
...		...
Delta SNR for space-time stream Nc for subcarrier $k = scidx(Ns - 1)$	4	$\Delta SNR_{scidx(Ns-1),Nc}$ as defined in Equation (9-2).

In Table 9-76f (HE MU Exclusive Beamforming Report information), *Ns* and *scidx()* are defined in 9.4.1.63 (HE Compressed Beamforming Report field).

9.4.1.65 HE CQI-only Report field

The HE CQI-only Report field is used by the HE Compressed Beamforming And CQI frame (see 9.6.28.2 (HE Compressed Beamforming And CQI frame format)) to carry the per-RU average SNRs of each space-time stream, where each per-RU average SNR is the arithmetic mean of the SNR in decibels over a 26-tone RU for which the feedback is being requested.

The size of the HE Compressed Beamforming Report field depends on the values in the HE MIMO Control field. The HE Compressed Beamforming Report field contains HE CQI-only Report information or successive (possibly zero-length) portions thereof in the case of segmented HE compressed beamforming and CQI feedback (see 27.6 (HE sounding protocol)). HE CQI-only Report information is included in the HE compressed beamforming and CQI feedback if the CQI-only feedback type is indicated in the Feedback Type

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field of the HE MIMO Control field. The structure of the HE CQI-only Report field is shown in Table 9-76g (HE CQI-only Report information).

Table 9-76g—HE CQI-only Report information

Field	Size (bits)	Meaning
Average SNR for space-time stream 1 for RU index k = *ruidx*(0)	6	SNR at the beamformee for space-time stream 1 averaged over 26-tone RU. See Table 9-76h (Average SNR of RU index k for space-time stream i subfield).
...		
Average SNR for space-time stream *Nc* for RU index k = *ruidx*(0)	6	SNR at the beamformee for space-time stream *Nc* averaged over 26-tone RU. See Table 9-76h (Average SNR of RU index k for space-time stream i subfield).
Average SNR for space-time stream 1 for RU index k = *ruidx*(1)	6	SNR at the beamformee for space-time stream 1 averaged over 26-tone RU. See Table 9-76h (Average SNR of RU index k for space-time stream i subfield).
...		
Average SNR for space-time stream *Nc* for RU index k = *ruidx*(1)	6	SNR at the beamformee for space-time stream *Nc* averaged over 26-tone RU. See Table 9-76h (Average SNR of RU index k for space-time stream i subfield).
...		
Average SNR for space-time stream 1 for RU index k = *ruidx*(*Ncqi* − 1)	6	SNR at the beamformee for space-time stream 1 averaged over 26-tone RU. See Table 9-76h (Average SNR of RU index k for space-time stream i subfield).
...		
Average SNR for space-time stream *Nc* for RU index k = *ruidx*(*Ncqi* − 1)	6	SNR at the beamformee for space-time stream *Nc* averaged over 26-tone RU. See Table 9-76h (Average SNR of RU index k for space-time stream i subfield).

Ncqi is the number of RU indices for which the CQI-only report is sent back to the beamformer. *Ncqi* is a function of the RU Start Index and RU End Index subfields in the HE MIMO Control field. The RU indices *ruidx*(0) and *ruidx*(*Ncqi* − 1) correspond to the RU Start Index and RU End Index subfields, respectively. The RU index *ruidx*(i) = *ruidx*(i − 1) + 1, where $1 \leq i \leq Ncqi - 2$.

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The Average SNR of space-time stream *i* for the RU index *k* subfield in the Table 9-76g (HE CQI-only Report information) is an 6-bit twos complement integer whose definition is shown in Table 9-76h (Average SNR of RU index k for space-time stream i subfield).

Table 9-76h—Average SNR of RU index *k* for space-time stream *i* subfield

Average SNR of RU index *k* for space-time stream *i*	$AvgSNR_{k,i}$ (dB)
−32	≤ −10
−31	−9
−30	−8
...	
30	52
31	≥ 53

The $AvgSNR_{k,i}$ in Table 9-76h (Average SNR of RU index k for space-time stream i subfield) is found by computing the arithmetic mean of the SNR per subcarrier in decibels for space-time stream *i* over the subcarriers in RU index *k* for which the feedback is being requested.

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9.4.2 Elements

9.4.2.1 General

Insert the following new rows into Table 9-77 (Element IDs) (header row shown for convenience):

Table 9-77—Element IDs

Element	Element ID	Element ID Extension	Extensible
HE Capabilities (see 9.4.2.237 (HE Capabilities element))	255	35	Yes
HE Operation (see 9.4.2.238 (HE Operation element))	255	36	Yes
UORA Parameter Set element (see 9.4.2.239 (UL OFDMA-based Random Access (UORA) Parameter Set element))	255	37	Yes
MU EDCA Parameter Set (see 9.4.2.240 (MU EDCA Parameter Set element))	255	38	Yes
Spatial Reuse Parameter Set element (see 9.4.2.243 (Spatial Reuse Parameter Set element))	255	39	Yes
NDP Feedback Report Parameter Set element (see 9.4.2.244 (NDP Feedback Report Parameter Set element))	255	41	Yes
BSS Color Change Announcement (see 9.4.2.241 (BSS Color Change Announcement element))	255	42	Yes
Quiet Time Period Setup (see 9.4.2.242 (Quiet Time Period element))	255	43	Yes
ESS Report	255	<ANA>	Yes

9.4.2.3 Supported Rates and BSS Membership Selectors element

Editor's Note: 11ak adds 124-125

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Insert a new last row in Table 9-78 (BSS membership selector value encoding) as follows:

Table 9-78—BSS membership selector value encoding

Value	Feature	Interpretation
126	HE PHY	Support for the mandatory features of Clause 28 is required in order to join the BSS that was the source of the Supported Rates and BSS Membership Selectors element or Extended Supported Rates and BSS Membership Selectors element containing this value.

9.4.2.6 TIM element

Change the 4th paragraph as follows:

The DTIM Count field indicates how many Beacon frames (including the current frame) appear before the next DTIM. A DTIM count of 0 indicates that the current TIM is a DTIM. The DTIM Count field is a single octet. When a TIM element is included in a TIM frame or FILS Discovery frame, the DTIM Count field is reserved.

Insert the following at the end of the subclause:

When included in TIM frames and FILS Discovery frames at the beginning of a broadcast TWT SP with the TWT flow identifier field set to 3 by an OPS AP the following apply:

— The DTIM Count field is reserved

— The DTIM Period field is reserved

— The bit number *N* in the traffic indication virtual bitmap that corresponds to an OPS STA with AID *N* is determined as follows:

- Bit number *N* in the traffic indication virtual bitmap is 0 if the OPS AP does not intend to transmit to the OPS STA including to trigger the OPS STA for an UL MU transmission during the TWT SP and before the next TWT SP.
- Otherwise, bit number *N* in the traffic indication virtual bitmap for the OPS STA is 1.

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9.4.2.27 Extended Capabilities element

Insert the following rows into Table 9-135 (Extended Capabilities element) (header row shown for convenience):

Table 9-135—Extended Capabilities element

Bit	Information	Notes
77	TWT Requester Support	A STA sets the TWT Requester Support field to 1 when dot11TWTOptionActivated is true, dot11HEOptionImplemented is true and TWT requester functionality is supported. Otherwise, the STA sets the TWT Requester Support field to 0. See 10.43 (Target wake time (TWT)).
78	TWT Responder Support	A STA sets the TWT Responder Support field to 1 when dot11TWTOptionActivated is true, dot11HEOptionImplemented is true and TWT responder functionality is supported. Otherwise, the STA sets the TWT Responder Support field to 0. See 10.43 (Target wake time (TWT)).
79	OBSS Narrow Bandwidth RU in UL OFDMA Tolerance Support	If operating in an operating class for which the behavior limits set listed in Annex E includes the DFS_50_100_Behavior then the following apply: — An AP STA sets the OBSS Narrow Bandwidth RU in UL OFDMA Tolerance Support field to 1 when dot11OBSSNarrowBWRUinULOFDMATolerated is true, and sets it to 0 otherwise. — A non-AP STA sets the OBSS Narrow Bandwidth RU in UL OFDMA Tolerance Support field to 0. If operating in an operating class for which the behavior limits set listed in Annex E does not include the DFS_50_100_Behavior then a STA sets the OBSS Narrow Bandwidth RU in UL OFDMA Tolerance Support field to 0.

9.4.2.37 Neighbor Report element

Change Figure 9-296 (BSSID Information field) as follows:

B0 B1	B2	B3	B4 B9	B10	B11	B12	B13	B14	B15	B14~~6~~ B31
AP Reachability	Security	Key Scope	Capabilities	Mobility Domain	High Throughput	Very High Throughput	FTM	High Efficiency	ER BSS	Reserved
Bits: 2	1	1	6	1	1	1	1	1	1	~~18~~16

Figure 9-296—BSSID Information field

Insert the following after the paragraph beginning "The FTM field...":

The High Efficiency subfield is set to 1 to indicate that the AP represented by this BSSID is an HE AP and that the HE Capabilities element, if included as a subelement in the report, is identical in content to the HE Capabilities element included in the AP's Beacon frame. Otherwise the High Efficiency subfield is set to 0.

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When the High Efficiency subfield is 1 the ER BSS subfield is set to 1 to indicate that the BSS corresponding to the HE AP representing this BSSID is an extended range BSS (see 27.16.5 (ER Beacon Generation in an ER BSS)). Otherwise the ER BSS subfield is set to 0.

Delete the paragraph "Bits 14-31 are reserved."

Insert new rows for subelement IDs 193 and 194 in Table 9-151 as follows and update the reserved row:

Table 9-151—Optional subelement IDs for Neighbor report

Subelement ID	Name	Extensible
193	HE Capabilities	Yes
194	HE Operation	Yes

9.4.2.46 Multiple BSSID element

Change the 7th paragraph as follows:

The Nontransmitted BSSID Profile subelement contains a list of elements for one or more APs or DMG STAs that have nontransmitted BSSIDs, and is defined as follows:

— For each nontransmitted BSSID, the Nontransmitted BSSID Capability element (see 9.4.2.72 (Nontransmitted BSSID Capability element)) is the first element included, followed by a variable number of elements, in the order defined in 9-27 (Beacon frame body).

— The SSID element (see 9.4.2.2 (SSID element)) and multiple BSSID-index ~~subelements~~ element (see 9.4.2.74 (Multiple BSSID-Index element)) are included in the Nontransmitted BSSID Profile subelement.

— The FMS Descriptor element is included in the Nontransmitted BSSID Profile subelement if the Multiple BSSID element is included in a Beacon frame and if the TIM field indicates there are buffered group addressed frames for this nontransmitted BSSID.

— The Timestamp and Beacon Interval fields, DSSS Parameter Set, IBSS Parameter Set, Country, Channel Switch Announcement, Extended Channel Switch Announcement, Wide Bandwidth Channel Switch, Transmit Power Envelope, Supported Operating Classes, IBSS DFS, ERP Information, HT Capabilities, HT Operation, VHT Capabilities, ~~and~~ VHT Operation, HE Capabilities, HE Operation, BSS Color Change Announcement, and Spatial Reuse Parameter Set elements are not included in the Nontransmitted BSSID Profile subelement; the values of these elements for each nontransmitted BSSID are always the same as the corresponding transmitted BSSID element values.

NOTE—A Nontransmitted BSSID Profile subelement may carry other element(s) if the content of the the element(s) are different for the nontransmitted BSSID than those for the transmitted BSSID.

9.4.2.67 Event Request element

9.4.2.67.1 Event Request definition

Insert a new row and update the first reserved row of Table 9-171 as follows:

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Table 9-171—Event Type field definitions for event requests and reports

Name	Event Type
BSS Color Collision	4
Reserved	4<u>5</u>–220

9.4.2.68 Event Report element

9.4.2.68.1 Event Report Definition

Change the 6th paragraph as follows:

The Event TSF, UTC Offset, Event Time Error, and Event Report fields are present only when the Event Report Status field is 0 <u>(Successful) and Event Type is not 4 (BSS Color Collision)</u>. <u>Event TSF and Event Report fields are present only when Event Status is 0 (Successful) and Event Type is 4 (BSS Color Collision).</u>

Change the 10th paragraph as follows:

The Event Report field contains the specification of a single event report, as described in 9.4.2.68.2 (Transition event report) to 9.4.2.68.5 (WNM log event report) <u>and 9.4.2.68.7 (BSS Color Collision event report)</u>.

Insert a new subclause at the end of 9.4.2.68:

9.4.2.68.7 BSS Color Collision event report

Event Report field is 8-octets in length with each bit representing a BSS color value. A value of 1 at a bit position indicates that the BSS color value corresponding to that position is in use by OBSS as detected by the reporting non-AP HE STA.

9.4.2.139 ADDBA Extension element

Change Figure 9-531 (ADDBA Capabilities field format) as follows:

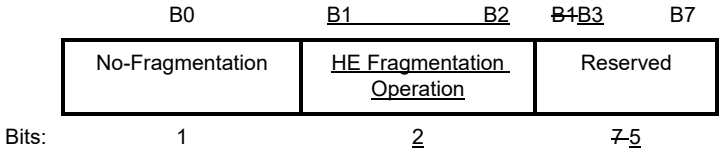


Figure 9-531—ADDBA Capabilities field format

Change the last paragraph as follows:

The No-Fragmentation subfield determines whether a fragmented MSDU can be carried in the MPDU sent under the block ack agreement. When this subfield set to 1 in the ADDBA Request frame, it indicates that the <u>non-HE</u> originator is not fragmenting sent MSDUs. When this subfield set to 1 in the ADDBA Response frame, it indicates that the <u>non-HE</u> recipient is not capable of receiving fragmented MSDUs. <u>The No-Fragmentation subfield is reserved when transmitted by an HE STA to another HE STA.</u>

Insert the following as the new last paragraph:

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The HE Fragmentation Operation subfield is reserved when transmitted by a non-HE STA. The HE Fragmentation Operation subfield when transmitted by an HE STA indicates the level of dynamic fragmentation that is supported as a recipient for the TID which is defined in the ADDBA frame as follows:

— A value of 0 in the ADDBA Request frame indicates that the originator does not intend to send fragmented MSDUs or A-MSDUs for the TID specified in the Block Ack Parameter Set field of the ADDBA Request frame.

— When this subfield set to 1 in the ADDBA Request frame, it indicates that the originator intends to send fragmented MSDUs or A-MSDU if supported by the recipient under fragmentation level 1 (see 27.3.2.2 (Level 1 dynamic fragmentation)) for the TID specified in the Block Ack Parameter Set field of the ADDBA Request frame.

— When this subfield set to 2 in the ADDBA Request frame, it indicates that the originator intends to send fragmented MSDUs or A-MSDU if supported by the recipient under fragmentation level 2 (see 27.3.2.3 (Level 2 dynamic fragmentation)) for the TID specified in the Block Ack Parameter Set field of the ADDBA Request frame.

— When this subfield set to 3 in the ADDBA Request frame, it indicates that the originator intends to send fragmented MSDUs or A-MSDU if supported by the recipient under fragmentation level 3 (see 27.3.2.4 (Level 3 dynamic fragmentation)) for the TID specified in the Block Ack Parameter Set field of the ADDBA Request frame.

— When this subfield set to 0 in the ADDBA Response frame, it indicates that the recipient is not capable of receiving fragmented MSDUs or A-MSDU if supported by the recipient for the TID specified in the Block Ack Parameter Set field of the ADDBA Response frame.

— When this subfield set to 1 in the ADDBA Response frame, it indicates that the recipient is capable of receiving fragmented MSDUs or A-MSDU if supported by the recipient under fragmentation level 1 only for the TID specified in the Block Ack Parameter Set field of the ADDBA Response frame.

— When this subfield set to 2 in the ADDBA Response frame, it indicates that the recipient is capable of receiving fragmented MSDUs or A-MSDU if supported by the recipient under fragmentation levels 1 and 2 for the TID specified in the Block Ack Parameter Set field of the ADDBA Response frame.

— When this subfield set to 3 in the ADDBA Response frame, it indicates that the recipient is capable of receiving fragmented MSDUs or A-MSDU if supported by the recipient under fragmentation levels 1, 2 and 3 for the TID specified in the Block Ack Parameter Set field of the ADDBA Response frame.

9.4.2.158 VHT Capabilities

9.4.2.158.3 Supported VHT-MCS and NSS Set field

Insert the following at the end of this subclause:

The value of Max VHT NSS for a given MCS is equal to the smaller of:

— The maximum value of n for which the Max VHT-MCS for n SS has a value that indicates support for that MAC (0, 1 or 2 for MCS 0-7, 1 or 2 for MCS 8, 2 for MCS 9)

— The maximum supported NSS as indicated in by the value of the Rx NSS field of the OM Control subfield (and further defined in the Table 9-18b (Setting of the VHT Channel Width and VHT NSS at a HE STA transmitting the OM Control subfield))

NOTE—A VHT-MCS indicated as supported in the VHT-MCS Map fields for a particular number of spatial streams might not be valid at all bandwidths (see 21.5 (Parameters for VHT-MCSs)), might be limited by the declaration of Tx Highest Supported Long GI Data Rates and Rx Highest Supported Long GI Data Rates, and might be affected by 10.7.12.3 (Additional rate selection constraints for VHT PPDUs) and the value of the Extended NSS BW Support field of the VHT Capabilities Information field in 9.4.2.158.2 (VHT Capabilities Information field) and the 160/80+80 BW subfield of the Operating Mode field in 9.4.1.53 (Operating Mode field).

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9.4.2.178 FILS Request Parameters element

Change Table 9-262b (PHY Support Criterion subfield) as follows:

Table 9-262b—PHY Support Criterion subfield

Value	Explanation
0	Indicates that PHY Support Criterion is not in use.
1	Indicates that a responding FILS STA is HT capable.
2	Indicates that a responding FILS STA is VHT capable.
3	Indicates that a responding FILS STA is HE capable.
~~3~~4-7	Reserved

9.4.2.200 TWT element

Change the first paragraph as follows:

The TWT element format when the Broadcast subfield of the Control field is 0 is shown in Figure 9-589av.

Replace the title of Figure 9-589av with "TWT element format when the Broadcast subfield is 0"

Insert a new paragraph and associated figure after the first paragraph as follows:

The TWT element format when the Broadcast subfield of the Control field is 1 is shown in Figure 9-589av1 (TWT element format when the Broadcast subfield is 1).

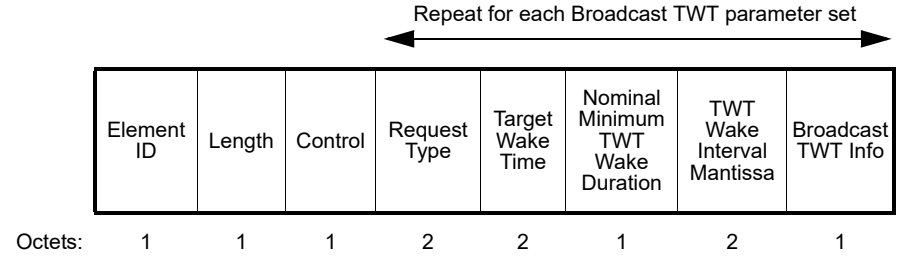


Figure 9-589av1—TWT element format when the Broadcast subfield is 1

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Change Figure 9-589aw (Control field format) as follows.

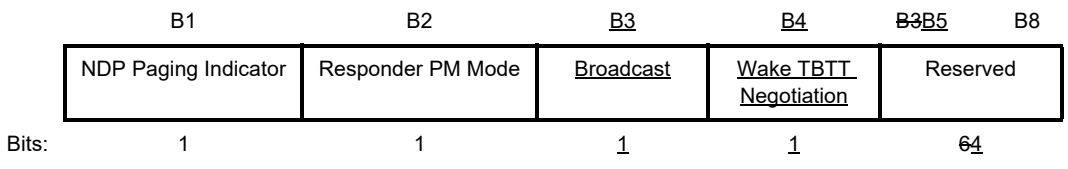


Figure 9-589aw—Control field format

Insert the following three paragraphs after the 5th paragraph ("The Responder PM Mode subfield..."):

The Broadcast field indicates if the TWT SP(s) indicated by the TWT element are for broadcast or individual TWT(s). The Broadcast field is set to 1 to indicate that the TWT SP(s) defined by the TWT element are associated with broadcast TWT(s). Otherwise, the Broadcast field is 0. When the Broadcast field is 1 then one or more broadcast TWT parameter sets are contained in the TWT element where each TWT parameter set contains the Request Type, Target Wake Time, Nominal Minimum TWT Wake Duration, TWT Wake Interval Mantissa and Broadcast TWT Info subfields. The Last Broadcast Parameter Set subfield is set to 1 in the last broadcast TWT parameter set of the element and is set to 0 in all other broadcast TWT parameter sets. When the Broadcast field is equal to 0, only one TWT parameter set is contained in the TWT element. An S1G STA sets the Broadcast field to 0.

The Wake TBTT Negotiation field and the Broadcast field determine the interpretation of the Target Wake Time, TWT Wake Interval Mantissa and TWT Wake Interval Exponent subfields of the TWT element as defined in Table 9-262j1 (Interpretation of Target Wake Time, TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields).

Table 9-262j1—Interpretation of Target Wake Time, TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields

Wake TBTT Negotiation and Broadcast subfields	Target Wake Time field	TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields	Description
Wake TBTT Negotiation = 0 Broadcast = 0	Individual TWT	Interval between individual TWT SPs	Individual TWT negotiation between TWT requesting STA and TWT responding STA. See 10.43 (Target wake time(TWT)), and 27.7.2 (Individual TWT agreements).

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Table 9-262j1—Interpretation of Target Wake Time, TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields *(continued)*

Wake TBTT Negotiation = 1 Broadcast = 0	Next Wake TBTT	Interval between wake TBTTs	Wake TBTT and wake interval negotiation between TWT scheduled STA and TWT scheduling AP. See 27.7.3.4 (Negotiation of wake TBTT and wake interval).
Wake TBTT Negotiation = 0 Broadcast = 1	Broadcast TWT	Interval between broadcast TWT SPs	Provide broadcast TWT schedules to TWT scheduled STAs by including the TWT element in broadcast MGMT frames sent by TWT scheduling AP. See 27.7.3.2 (Rules for TWT scheduling AP).
Wake TBTT Negotiation = 1 Broadcast = 1	Broadcast TWT	Interval between broadcast TWT SPs	Manage memberships in broadcast TWT schedules by including the TWT element in individually addressed MGMT frames sent by either a TWT scheduled STA or a TWT scheduling AP. See 27.7.3 (Broadcast TWT operation).

Change Figure 9-589ax (Request Type field format) as follows (B4 from "Reserved" to "Trigger").

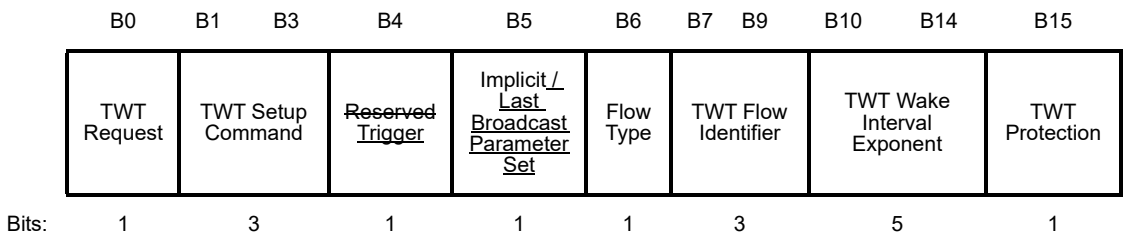


Figure 9-589ax—Request Type field format

Change the 6th paragraph as follows:

A STA that transmits a TWT element with the TWT Request subfield equal to 1 is a TWT requesting STA or TWT scheduled STA. Otherwise, it is a TWT responding STA or TWT scheduling AP.

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Change Table 9-262k (TWT Setup Command field values) as follows:

Table 9-262k—TWT Setup Command field values

TWT Setup Command field value	Command name	~~Description when transmitted by a TWT requesting STA~~ Description	~~Description when transmitted by a TWT responding STA~~
0	Request TWT	~~The Target Wake Time field of the TWT element contains 0s as the TWT responding STA specifies the target wake time value for this case, other TWT parameters* are suggested by the TWT requesting STA in the TWT request.~~ A TWT requesting or TWT scheduled STA requests to join a TWT without specifying a target wake time. This command is valid if the TWT Request field is equal to 1; otherwise the command is not applicable.	~~N/A~~
1	Suggest TWT	~~TWT requesting STA includes a set of TWT parameters such that if the requested target wake time value and/or other TWT parameters cannot be accommodated, then the TWT setup might still be accepted.~~ A TWT requesting or TWT scheduled STA requests to join a TWT and specifies a suggested set of TWT parameters with the possibility that if the requested target wake time and/or other TWT parameters cannot be accommodated, then the TWT setup might still be accepted by the TWT requesting or TWT scheduled STA. This command is valid if the TWT Request field is equal to 1; otherwise it is not applicable.	~~N/A~~
2	Demand TWT	~~TWT requesting STA includes a set of TWT parameters such that if the requested target wake time value and/or other TWT parameters cannot be accommodated, then the TWT setup will be rejected.~~ A TWT requesting or TWT scheduled STA requests to join a TWT and specifies a demanded set of TWT parameters which, if not accommodated by the responding STA or TWT scheduling AP will cause the TWT requesting STA or TWT scheduled STA to reject the TWT setup. This command is valid if the TWT Request field is equal to 1; otherwise it is not applicable.	~~N/A~~

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Table 9-262k—TWT Setup Command field values *(continued)*

3	TWT Grouping	~~N/A~~ The TWT responding STA suggests TWT group parameters that are different from the suggested or demanded TWT parameters of the TWT requesting STA This command is valid if the TWT Request field is 0 and Wake TBTT Negotiation field is 0 and is sent by an S1G STA; otherwise not applicable.	~~TWT responding STA suggests TWT group parameters that are different from the suggested or demanded TWT parameters of the TWT requesting STA~~
4	Accept TWT	~~N/A~~ A TWT responding STA or TWT scheduling AP accepts the TWT request with the TWT parameters (see NOTE) indicated in the TWT element transmitted by the TWT responding STA or TWT scheduling AP. This command is valid if the TWT Request field is 0; otherwise not applicable.	~~TWT responding STA accepts the TWT request with the TWT parameters (See NOTE) indicated in the TWT element transmitted by the responding STA~~
5	Alternate TWT	~~N/A~~ A TWT responding STA suggests TWT parameters that are different from those suggested or demanded by the TWT requesting STA. This command is valid if the TWT Request field is 0; otherwise not applicable.	~~TWT responding STA suggests TWT parameters that are different from TWT requesting STA suggested or demanded TWT parameters~~
6	Dictate TWT	N/A	~~TWT responding STA demands TWT parameters that are different from TWT requesting STA TWT suggested or demanded parameters~~
7	Reject TWT	N/A	~~TWT responding STA rejects TWT setup~~
NOTE—TWT Parameters are: TWT, Nominal Minimum Wake Duration, TWT Wake Interval and TWT Channel subfield values indicated in the element. The Trigger subfield value indicated in the element is also a TWT parameter for an HE STA.			

Insert the following paragraph after the 7th paragraph ("The TWT Setup Command subfield..."):

The Trigger field indicates whether or not the TWT SP indicated by the TWT element includes Trigger frames as defined in 10.43 (Target wake time (TWT)). The Trigger field is set to 1 to indicate that at least one Trigger frame is transmitted during the TWT SP. The Trigger field is set to 0 otherwise.

Change the 8th and 9th paragraphs as follows:

When transmitted by a TWT requesting STA, the Implicit / Last Broadcast Parameter Set subfield is set to 1 and the Broadcast subfield is set to 0 to request an implicit TWT.

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When transmitted by a TWT requesting STA, the Implicit / Last Broadcast Parameter Set subfield is set to 0 and the Broadcast subfield is set to 0 to request an explicit TWT.

When the Broadcast subfield is equal to 1, the Implicit / Last Broadcast Parameter Set subfield is set to 0 to indicate that another broadcast TWT Parameter set follows this set. When the Broadcast subfield is equal to 1, the Implicit / Last Broadcast Parameter Set subfield is set to 1 to indicate that this is the last broadcast TWT Parameter set in the element.

Change the 11th paragraph as follows:

The TWT Flow Identifier subfield contains a 3-bit value which identifies the specific information for this TWT request uniquely from other requests made between the same TWT requesting STA and TWT responding STA pair. For a TWT SP that is indicated in a TWT response transmission that is a broadcast TWT SP, the TWT Flow Identifier subfield contains a value that indicates recommendations on the types of frames that are transmitted by TWT scheduled STAs and scheduling AP during the broadcast TWT SP, encoded according to Table 9-262k1 (TWT Flow Identifier field for a broadcast TWT element). The TWT Flow Identifier is reserved when transmitted by a TWT scheduled STA except when used as defined in 27.7.3.4 (Negotiation of wake TBTT and wake interval).

Insert a new table as follows:

Table 9-262k1—TWT Flow Identifier field for a broadcast TWT element

TWT Flow Identifier field value	Description when transmitted in a broadcast TWT element
0	No constraints on the frames transmitted during a broadcast TWT SP.
1	Frames transmitted during a broadcast TWT SP by a TWT scheduled STA are recommended to be limited to solicited feedback and status: — PS-Poll and QoS Null frames and HT TB NDP PPDUs — Feedback can be contained in the QoS Control field or in the HE variant HT Control field of the frame, if either is present (see 27.5.1 (HE DL MU operation), 27.5.3 (UL MU operation), 27.8 (Operating mode indication), 27.13 (Link adaptation using the HLA Control field), etc.) — Frames that are sent as part of a sounding feedback exchange (see 27.6 (HE sounding protocol)) — Management frames: Action or Action No Ack frames — Control response frames Trigger frames transmitted by the TWT scheduling AP during the broadcast TWT SP do not contain RUs for random access (see 27.7.3.2 (Rules for TWT scheduling AP)), otherwise, there are no other restrictions on the frames transmitted by the TWT scheduling AP..

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Table 9-262k1—TWT Flow Identifier field for a broadcast TWT element

2	Frames transmitted during a broadcast TWT SP by a TWT scheduled STA are recommended to be limited to solicited status and feedback: — PS-Poll and QoS Null frames — Feedback can be contained in the QoS Control field or in the HE variant HT Control field of the frame, if either is present (see 27.5.1 (HE DL MU operation), 27.5.3 (UL MU operation), 27.8 (Operating mode indication), 27.13 (Link adaptation using the HLA Control field), etc.) — Frames that are sent as part of a sounding feedback exchange (see 27.6 (HE sounding protocol)) — Management frames: Action, Action No Ack frames or (Re)Association Request frames — Control response frames Trigger frames transmitted by the TWT scheduling AP during the broadcast TWT SP contain at least one RU for random access (see 27.7.3.2 (Rules for TWT scheduling AP)), otherwise there are no restrictions on the frames transmitted by the TWT scheduling AP..
3	No constraints on the frames transmitted during a broadcast TWT SP except that the AP transmits a TIM frame or a FILS Discovery frame including a TIM element at the beginning of each TWT SP (see 27.14.3.2 (AP operation for opportunistic power save)).
4-7	Reserved

Change the 12th and 13th paragraphs as follows:

In a TWT element transmitted by a TWT requesting or TWT scheduled STA, the TWT wake interval is equal to the average time that the ~~TWT requesting~~ STA expects to elapse between successive TWT SPs (see Table 9-262j1 (Interpretation of Target Wake Time, TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields)). In a TWT element transmitted by a TWT responding STA or TWT scheduling AP, the TWT wake interval is equal to the average time that the ~~TWT responding~~ STA expects to elapse between successive TWT SPs. In a TWT element contained in a TWT request that is sent by the scheduled STA to negotiate the wake intervals for Beacon frames that contain a TWT element that indicates a broadcast TWT, the TWT wake interval indicates the value of the wake interval (see 27.7.3.4 (Negotiation of wake TBTT and wake interval)). The TWT Wake Interval Exponent subfield is set to the value of the exponent of the TWT wake interval value in microseconds, base 2. The TWT wake interval of the requesting STA is equal to (TWT Wake Interval Mantissa) × $2^{(\text{TWT Wake Interval Exponent})}$.

When transmitted by a TWT requesting STA or a TWT scheduled STA, the Target Wake Time field contains a positive integer ~~which~~ that corresponds to a TSF time at which the STA requests to wake, or a value of zero when the TWT Setup Command subfield contains the value corresponding to the command "Request TWT". The Target Wake Time field is 8 octets when the Broadcast field is 0; otherwise it is 2 octets with the lowest bit of the 2 octets corresponding to bit 4 of the relevant TSF value. When a TWT responding STA or a TWT scheduling AP with dot11TWTGroupingSupport equal to 0 transmits a TWT element to the TWT requesting STA, the TWT element contains a value in the Target Wake Time field ~~which~~ that corresponds to a TSF time at which the TWT responding STA requests the TWT requesting STA or TWT scheduled STA to wake for the corresponding TWT SP and it does not contain the TWT Group Assignment field.

Insert the following paragraphs and figure after paragraph 21 ("The TWT Wake Interval Mantissa..."):

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The Broadcast TWT Info subfield is present if the Broadcast subfield in the Control subfield is 1; otherwise, the Broadcast TWT Info subfield is not present. The Broadcast TWT Info subfield contains the Broadcast TWT ID subfield and the Broadcast TWT Persistence subfield as shown in Figure 9-589ay1 (Broadcast TWT Info subfield format).

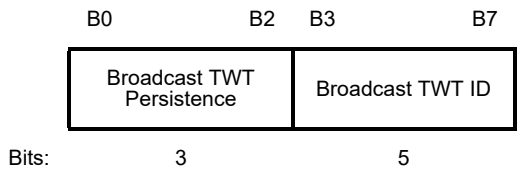


Figure 9-589ay1—Broadcast TWT Info subfield format

The Broadcast TWT Persistence subfield indicates the number of beacon intervals during which the Broadcast TWT SPs corresponding to this broadcast TWT Parameter set are present. The number of beacon intervals during which the Broadcast TWT SPs are present is equal to the value in the Broadcast TWT Persistence subfield plus 1, except that the value of 7 indicates that the Broadcast TWT SPs are present for every beacon interval, until explicitly terminated.

Within a TWT element that includes a TWT setup command value of Request TWT, Suggest TWT or Demand TWT, the Broadcast TWT ID, if present, indicates a specific Broadcast TWT in which the transmitting STA is requesting to participate. Within a TWT element that includes a TWT setup command value of Accept TWT, Alternate TWT, Dictate TWT or Reject TWT, the Broadcast TWT ID, if present, indicates a specific Broadcast TWT for which the transmitting STA is providing TWT parameters. Within a TWT element that includes a TWT setup command value of TWT Grouping, the Broadcast subfield is 0 and the Broadcast TWT ID~~,~~ is not present. The value 0 in the Broadcast TWT ID subfield indicates the special broadcast TWT whose membership corresponds to all STAs that are members of the BSS corresponding to the BSSID of the management frame carrying the TWT element.

Change the 22nd and subsequent two paragraphs as follows:

When transmitted by a TWT requesting STA that is not an S1G STA, the TWT Channel field is reserved. When transmitted by a TWT requesting STA that is an S1G STA, the TWT Channel field contains a bitmap indicating which channel the STA requests to use as a temporary primary channel during a TWT SP. When transmitted by a TWT responding STA that is an S1G STA, the TWT Channel field contains a bitmap indicating which channel the TWT requesting STA is allowed to use as a temporary channel during the TWT SP. Each bit in the bitmap corresponds to one minimum width channel for the band in which the TWT responding STA's associated BSS is currently operating, with the least significant bit corresponding to the lowest numbered channel of the operating channels of the BSS. The minimum width channel is equal to the SST Channel Unit field of the SST Operation element if such an element has been previously received or is equal to 1 MHz for a BSS with a BSS primary channel width of 1 MHz and 2 MHz for a BSS with a BSS primary channel width of 2 MHz if no such element has been previously received from the AP to which the SST STA is associated. A value of 1 in a bit position in the bitmap transmitted by a TWT requesting STA means that operation with that channel as the primary channel is requested during a TWT SP. A value of 1 in a bit position in the bitmap transmitted by a TWT responding STA means that operation with that channel as the primary channel is allowed during the TWT SP. The TWT Channel field is not present when the Broadcast field has the value 1.

~~A TWT requesting STA sets the TWT Protection subfield to 1 to request the TWT responding STA to provide protection of the set of TWT SPs corresponding to the requested TWT flow identifier by allocating RAW(s) that restrict access to the medium during the TWT SP(s) for that(those) TWTs. A TWT requesting STA sets the TWT Protection subfield to 0 if TWT protection by RAW allocation is not requested for the corresponding TWT(s).~~

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A TWT requesting STA sets the TWT Protection subfield to 1 to request the TWT responding STA to provide protection of the set of TWT SPs corresponding to the requested TWT flow identifier by:

— Allocating RAW(s) that restrict access to the medium during the TWT SP(s) for the TWTs that are set up within an S1G BSS

— Enabling NAV protection during the TWT SP(s) for the TWTs that are set up within an HE BSS

A TWT requesting STA sets the TWT Protection subfield to 0 if TWT protection is not requested for the corresponding TWT(s).

A TWT scheduled STA sets the TWT Protection subfield to 0.

~~When transmitted by a TWT responding STA that is an AP, the TWT Protection subfield indicates whether the TWT SP(s) identified in the TWT element will be protected. A TWT responding STA sets the TWT Protection subfield to 1 to indicate that the TWT SP(s) corresponding to the TWT flow identifier(s) of the TWT element will be protected by allocating RAW(s) that restrict access to the medium during the TWT SP(s) for that(those) TWT(s). A TWT responding STA sets the TWT Protection subfield to 0 to indicate that the TWT SP(s) identified in the TWT element might not be protected from TIM STAs by allocating RAW(s).~~

When transmitted by a TWT responding STA or TWT scheduling AP, the TWT Protection subfield indicates whether the TWT SP(s) identified in the TWT element will be protected. A TWT responding STA or TWT scheduling AP sets the TWT Protection subfield to 1 to indicate that the TWT SP(s) corresponding to the TWT flow identifier(s) of the TWT element will be protected by:

— Allocating RAW(s) that restrict access to the medium during the TWT SP(s) for the TWTs where the responding STA or scheduling STA is an S1G STA.

— Enabling NAV protection during the TWT SP(s) for the TWTs where the responding STA or scheduling AP is an HE STA.

A TWT responding STA or TWT scheduling AP sets the TWT Protection subfield to 0 to indicate that the TWT SP(s) identified in the TWT element might not be protected.

Insert the following new subclauses after the last subclause in 9.4.2:

9.4.2.237 HE Capabilities element

9.4.2.237.1 General

An HE STA declares that it is an HE STA by transmitting the HE Capabilities element.

The HE Capabilities element contains a number of fields that are used to advertise the HE capabilities of an HE STA. The HE Capabilities element is defined in Figure 9-589cj (HE Capabilities element format).

	Element ID	Length	Element ID Extension	HE MAC Capabilities Information	HE PHY Capabilities Information	Tx Rx HE-MCS NSS Support	PPE Thresholds (optional)
Octets:	1	1	1	5	9	4, 8 or 12	variable

Figure 9-589cj—HE Capabilities element format

The Element ID, Length, and Element ID Extension fields are defined in 9.4.2.1 (General).

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The HE MAC Capabilities Information, HE PHY Capabilities Information, Tx Rx HE-MCS NSS Support, and PPE Thresholds fields are defined in the subclauses below.

9.4.2.237.2 HE MAC Capabilities Information field

The format of the HE MAC Capabilities Information field is defined in Figure 9-589ck (HE MAC Capabilities Information field format).

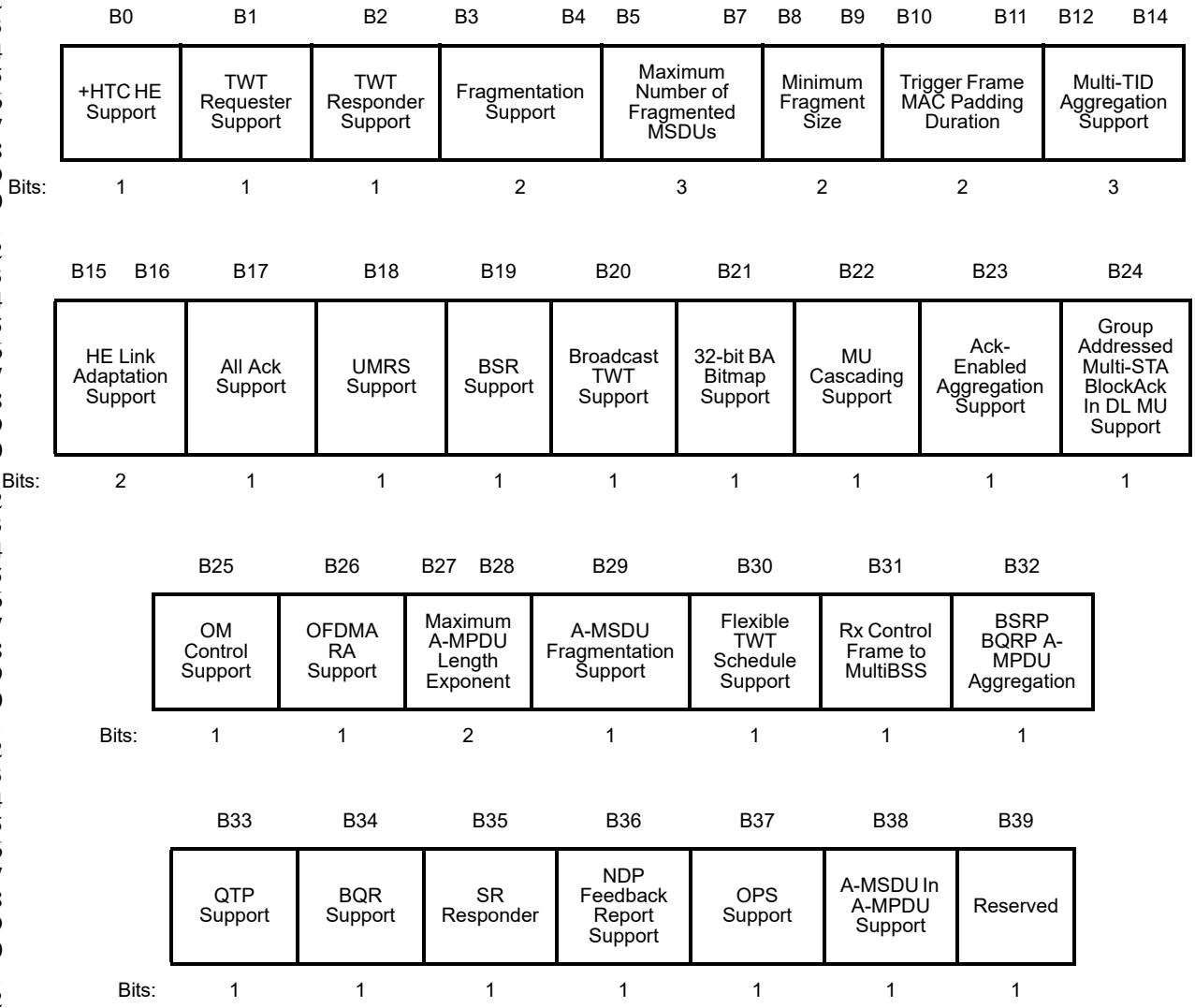


Figure 9-589ck—HE MAC Capabilities Information field format

The subfields of the HE MAC Capabilities Information field are defined in Table 9-262z (Subfields of the HE MAC Capabilities Information field).

Table 9-262z—Subfields of the HE MAC Capabilities Information field

Subfield	Definition	Encoding

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Table 9-262z—Subfields of the HE MAC Capabilities Information field *(continued)*

+HTC-HE Support	Indicates support for the reception of an HE variant HT Control field carried in a QoS Data, QoS Null, or Management frame.	Set to 1 if the STA supports reception of an HE variant HT Control field. Set to 0 otherwise.
TWT Requester Support	Indicates support for the role of TWT requesting STA as described in 27.7 (TWT operation)).	Set to 1 if dot11TWTOptionActivated is true and the STA supports TWT requesting STA functionality (see 27.7 (TWT operation)). Set to 0 otherwise.
TWT Responder Support	Indicates support for the role of TWT responder STA as described in 27.7 (TWT operation)).	Set to 1 if dot11TWTOptionActivated is true and the STA supports TWT responder STA functionality (see 27.7 (TWT operation)). Set to 0 otherwise.
Fragmentation Support	Indicates the level of dynamic fragmentation that is supported by a STA as a recipient.	Set to 0 for no support for dynamic fragmentation. Set to 1 for support for dynamic fragments that are contained within an MPDU or S-MPDU, no support for dynamic fragments within an A-MPDU that is not an S-MPDU. Set to 2 for support for dynamic fragments that are contained within an MPDU or S-MPDU and support for up to one dynamic fragment for each MSDU, each A-MSDU if supported by the recipient, and each MMPDU within an A-MPDU or multi-TID A-MPDU that is not an MPDU or S-MPDU. Set to 3 for support for dynamic fragments that are contained within an MPDU or S-MPDU and support for multiple dynamic fragments for each MSDU and for each A-MSDU if supported by the recipient within an A-MPDU or multi-TID AMPDU and up to one dynamic fragment for each MMPDU in a multi-TID A-MPDU that is not an S-MPDU.
Maximum Number Of Fragmented MSDUs	Indicates the maximum number of fragmented MSDUs that the STA is capable of receiving concurrently.	If the Fragmentation Support subfield is greater than 0: The maximum number of fragmented MSDUs, N_{max}, defined by this field is $N_{max} = 2^{\text{Maximum Number Of F-MPDUs}}$, except that a value 7 in the Maximum Number Of Fragmented MSDUs subfield indicates that there is no restriction. Reserved if the Fragmentation Support subfield is 0.
Minimum Fragment Size	Indicates the minimum payload size in octets of the first fragment of an MSDU that is supported by the STA.	If the Fragmentation Support subfield is greater than 0: Set to 0 to indicate no restriction on the minimum payload size. Set to 1 to indicate a minimum payload size of 128 octets. Set to 2 to indicate a minimum payload size of 256 octets. Set to 3 to indicate a minimum payload size of 512 octets. Reserved if the Fragmentation Support subfield is 0.

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Table 9-262z—Subfields of the HE MAC Capabilities Information field *(continued)*

Trigger Frame MAC Padding Duration	Indicates the additional amount of time defined as *MinTrigProcTime*, in microseconds, needed for a non-AP STA to process a received Trigger frame.	Set to 0 to indicate no additional processing time. Set to 1 to indicate 8 μs of processing time. Set to 2 to indicate 16 μs of processing time. The value 3 is reserved.
Multi-TID Aggregation Support	Indicates the number of TIDs minus 1 of QoS Data frames that an HE STA can aggregate in a multi-TID A-MPDU as described in 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU).	Set to the number of TIDs minus 1 of QoS Data frames that an HE STA can aggregate in a multi-TID A-MPDU.
HE Link Adaptation Support	Indicates support for link adaptation using the HLA Control field.	If +HTC-HE Support is 1: Set to 0 (No Feedback) if the STA does not provide HE MFB. Set to 2 (Unsolicited) if the STA can receive and provide only unsolicited HE MFB. Set to 3 (Both) if the STA is capable of receiving and providing HE MFB in response to HE MRQ and if the STA can receive and provide unsolicited HE MFB. The value 1 is reserved. Reserved if +HTC-HE Support is 0.
All ACK Support	Indicates support for the reception of a Multi-STA BlockAck frame under the all ack context (see 27.4.2 (Acknowledgement context in a Multi-STA BlockAck frame))	Set to 1 if supported. Set to 0 otherwise.
UMRS Support	Indicates support for receiving an MPDU that contains a UMRS Control field.	If +HTC-HE Support is 1: Set to 1 if the STA supports reception of the UMRS Control field. Set to 0 otherwise. Reserved if +HTC-HE Support is 0.
BSR Support	For an AP, indicates support for receiving an (A-)MPDU that contains a BSR Control field. For a non-AP STA, indicates support for generating an (A-)MPDU that contains a BSR Control field.	If +HTC-HE Support is 1: Set to 1 if the STA supports the BSR Control field functionality. Set to 0 otherwise. Reserved if +HTC-HE Support is 0.
Broadcast TWT Support	For a non-AP STA, indicates support for the role of TWT scheduled STA. For an AP indicates support for the role of TWT scheduling AP as described in 27.7.3 (Broadcast TWT operation).	Set to 1 when the STA supports broadcast TWT functionality. Set to 0 otherwise.
32-bit BA Bitmap Support	Indicates support for the reception of a Multi-STA BlockAck frame that has a 32-bit BlockAck Bitmap intended to it.	Set to 1 if the STA supports reception of a Multi-STA BlockAck frame that has a 32-bit Block Ack Bitmap subfield intended to it. Set to 0 otherwise.

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Table 9-262z—Subfields of the HE MAC Capabilities Information field *(continued)*

MU Cascading Supported	Indicates support for participating in an MU cascading sequence (see 27.6 (HE sounding protocol)).	Set to 1 if the STA supports MU cascading operation. Set to 0 otherwise.
Ack-Enabled Aggregation Support	Indicates support by a STA to receive an A-MPDU that contains two or more frames at leat one of which solicits an Ack frame or acknowledgment context in a Multi-STA BlockAck frame as described in 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU) and 27.5.1.1 (General).	Set to 1 if the STA supports reception of this A-MPDU format. Set to 0 otherwise.
Group Addressed Multi-STA Block-Ack In DL MU Support	For a non-AP STA, indicates support for the reception of a group-addressed Multi-STA BlockAck frame that is sent in a DL MU PPDU in a non-broadcast RU.	Set to 1 when the STA supports its reception. Set to 0 otherwise.
OM Control Support	Indicates support for receiving an MPDU that contains an OM Control field.	If +HTC-HE Support is 1: Set to 1 if the STA supports reception of the OM Control field. Set to 0 otherwise. Reserved if +HTC-HE Support is 0.
OFDMA RA Supports	For a non-AP STA, indicates support for the OFDMA random access procedure. For an AP, indicates support for sending Trigger frames that allocate random access RUs. See 27.5.5 (UL OFDMA-based random access (UORA)).	Set to 1 if supported. Set to 0 otherwise.
Maximum A-MPDU Length Exponent		
A-MSDU Fragmentation Support	The A-MSDU Fragmentation Support subfield indicates support for the reception of fragmented A-MSDUs.	Set to 1 to indicate support for the receipt of fragmented A-MSDUs. Set to 0 to indicate that reception of fragmented A-MSDUs is not supported.
Flexible TWT Schedule Support	Indicates support for the reception of TWT Information frames with any nonzero value in the Next TWT field.	Set to 1 if the STA supports reception of a TWT Information frame with a nonzero value in the Next TWT field. Set to 0 otherwise.
Rx Control Frame to MultiBSS	Indicates whether the non-AP STA when associated with a BSS corresponding to a nontransmitted BSSID supports reception of a control frame with TA equal to the transmitted BSSID	Set to 1 if supported. Set to 0 otherwise.

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Table 9-262z—Subfields of the HE MAC Capabilities Information field *(continued)*

BSRP BQRP A-MPDU Aggregation	Indicates whether or not the STA accepts a BSRP Trigger frame or BQRP Trigger frame that is aggregated with other control, data and management frames in an A-MPDU destined to the STA	Set to 1 if supported. Set to 0 otherwise.
QTP Support	Indicates support for quiet time period (QTP) operation as described in 27.16.4 (Quiet HE STAs in an HE BSS).	Set to 1 if supported. Set to 0 otherwise.
BQR Support	For an AP, indicates support for receiving an MPDU that contains a BQR Control field. For a non-AP STA, indicates support for generating an MPDU that contains a BQR Control field.	If +HTC-HE Support is 1: Set to 1 if the STA supports the BQR Control field functionality. Set to 0 otherwise. Reserved if +HTC-HE Support is 0.
SR Responder	Indicates support for the role of SR Responder.	Set to 1 if the STA supports the role of SR Responder. Set to 0 otherwise.
NDP Feedback Report Support	For a non-AP STA, indicates support for the NDP feedback report procedure and responding to the NDP Feedback Report Poll Trigger frame.	Set to 1 if supported. Set to 0 otherwise.
OPS Support	For an AP, indicates support for encoding OPS information in the TIM element of FILS Discovery frames or TIM frames as described in 27.14.3.2 (AP operation for opportunistic power save). For a non-AP STA, indicates support for receiving the opportunistic power save encoded TIM elements.	Set to 1 if supported. Set to 0 otherwise.
A-MSDU In A-MPDU Support	Indicates support by a STA to receive an ack-enabled A-MPDU in which an A-MSDU is carried in a QoS Data frame for which no block ack agreement exists.	Set to 1 if supported. Set to 0 otherwise.

If the HE STA includes a VHT Capabilities element, the Maximum A-MPDU Length Exponent subfield in the HE Capabilities element combined with the Maximum A-MPDU Length Exponent subfield in the VHT Capabilities element indicate the maximum A-MPDU length that the STA can receive with EOF padding not included in this limit. If the Maximum A-MPDU Length Exponent subfield in HE Capabilities element is 0, then the value of the Maximum A-MPDU Length Exponent subfield in the VHT Capabilities element indicates the maximum A-MPDU length that the STA can receive following the definition in 9.4.2.158.2 (VHT Capabilities Info field). If the Maximum A-MPDU Length Exponent subfield in the HE Capabilities element is 1 or 2, then the value in the Maximum A-MPDU Length Exponent subfield in the VHT Capabilities element is 7 and the maximum A-MPDU length is $2^{(20 + \text{Maximum A-MPDU Length Exponent subfield in the HE Capabilities element})} - 1$. The value 3 in the Maximum A-MPDU Length Exponent subfield in the HE Capabilities element is reserved.

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If the HE STA does not include the VHT Capabilities element, then the Maximum A-MPDU Length Exponent subfield in the HE Capabilities element combined with the Maximum A-MPDU Length Exponent subfield in the HT Capabilities element indicate the maximum A-MPDU length that the STA can receive with EOF padding not included in this limit. If the Maximum A-MPDU Length Exponent subfield in the HE Capabilities element is 0, then the value in the Maximum A-MPDU Length Exponent subfield in the HT Capabilities element indicates the maximum A-MPDU length that the STA can receive following the definition in 9.4.2.56.3 (HT Capabilities Info field). If the Maximum A-MPDU Length Exponent subfield in the HE Capabilities element is 1 or 2, then the value in the Maximum A-MPDU Length Exponent subfield in the HT Capabilities element is 7 and the maximum A-MDU length is $2^{(16 + \text{Maximum A-MPDU Length Exponent subfield in the HE Capabilities element})} - 1$. The value 3 in the Maximum A-MPDU Length Exponent subfield in the HE Capabilities element is reserved.

9.4.2.237.3 HE PHY Capabilities Information field

The format of the HE PHY Capabilities Information field is defined in Figure 9-589cl (HE PHY Capabilities Information field format).

	B0	B1 B7	B8 B11	B12	B13	B14	B15 B16	B17
	Dual Band Support	Channel Width Set	Punctured Preamble Rx	Device Class	LDPC Coding In Payload	HE SU PPDU With 1x HE-LTF And 0.8 μs GI	Midamble Rx Max NSTS	NDP With 4x HE-LTF And 3.2 ms GI
Bits:	1	7	4	1	1	1	2	1

	B18	B19	B20	B21	B22	B23	B24 B25	B26
	STBC Tx ≤ 80 MHz	STBC Rx ≤ 80 MHz	Doppler Tx	Doppler Rx	Full Bandwidth UL MU-MIMO	Partial Bandwidth UL MU-MIMO	DCM Max Constellation Tx	DCM Max NSS Tx
Bits:	1	1	1	1	1	1	2	1

	B27 B28	B29	B30	B31	B32	B33	B34 B36	B37 B39
	DCM Max Constellation Rx	DCM Max NSS Rx	Rx HE MU PPDU From Non-AP STA	SU Beamformer	SU Beamformee	MU Beamformer	Beamformee STS ≤ 80 MHz	Beamformee STS > 80 MHz
Bits:	2	1	1	1	1	1	3	3

	B40 B42	B43 B45	B46	B47	B48	B49	B50
	Number Of Sounding Dimensions ≤ 80 MHz	Number Of Sounding Dimensions > 80 MHz	Ng = 16 SU Feedback	Ng = 16 MU Feedback	Codebook Size (ϕ, ψ) = {4, 2} SU Feedback	Codebook Size (ϕ, ψ) = {7, 5} MU Feedback	Triggered SU Beamforming Feedback
Bits:	3	3	1	1	1	1	1

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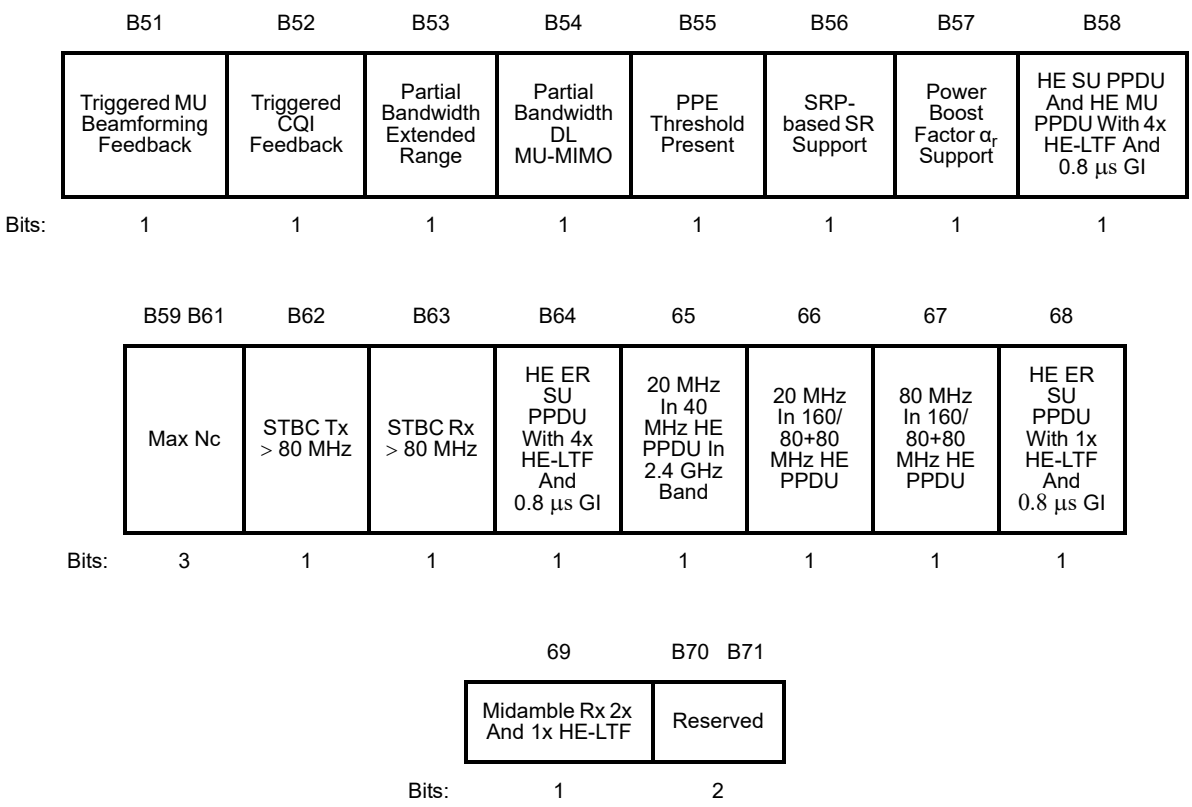


Figure 9-589cl—HE PHY Capabilities Information field format

The subfields of the HE PHY Capabilities Information field are defined in Table 9-262aa (Subfields of the HE PHY Capabilities Information field).

Table 9-262aa—Subfields of the HE PHY Capabilities Information field

Subfield	Definition	Encoding
Dual Band Support	Indicates support of both 2.4 GHz and 5 GHz frequency bands	Set to 0 if not supported. Set to 1 if supported.

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Table 9-262aa—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
Channel Width Set	B0 indicates support for a 40 MHz channel width in the 2.4 GHz band. B1 indicates support for a 40 MHz and 80 MHz channel width in the 5 GHz band. B2 indicates support for a 160 MHz channel width in the 5 GHz band. B3 indicates support for a 160/80+80 MHz channel width in the 5 GHz band. If a non-AP STA operates with 20 MHz channel width and 20 MHz In 40 MHz HE PPDU In 2.4 GHz subfield is 1, then B4 indicates support of 242-tone RUs in a 40 MHz HE MU PPDU in the 2.4 GHz band. Otherwise, B4 is reserved. If a non-AP STA operates with 20 MHz channel width and 20 MHz In 160/80+80 MHz HE PPDU subfield is set to 0, then B5 indicates support of 242-tone RUs in a 40 MHz and 80 MHz HE MU PPDU in the 5 GHz band. If a non-AP STA operates with 20 MHz channel width and 20 MHz In 160/80+80 MHz HE PPDU subfield is set to 1, then B5 indicates support of 242-tone RUs in a 40 MHz, 80 MHz, 160 MHz, and 80+80 MHz HE MU PPDU in the 5 GHz band. Otherwise, B5 is reserved. B6 is reserved. B0 and B4 are applicable to 2.4 GHz band operation and reserved for 5 GHz band operation. B1, B2, B3 and B5 are applicable to 5 GHz band operation and reserved for 2.4 GHz band operation.	B0 is set to 0 if not supported. B0 set to 1 if supported. B1 is set to 0 if not supported, i.e., it indicates a 20 MHz-only non-AP HE STA in 5 GHz. B1 set to 1 if supported. NOTE 1—For an AP, B1 is set to 1. B2 is set to 0 if not supported. B2 set to 1 if supported. If B2 set to 1 then B1 is set to 1. B3 is set to 0 if not supported. B3 is set to 1 if supported. If B3 set to 1 then B2 is set to 1. B4 is set to 0 if not supported. B4 set to 1 if supported. B5 set to 0 if not supported. B5 set to 1 if supported. NOTE 2—B4 is set to 0, if a non-AP STA operates with 20 MHz channel width and the 20 MHz In 40 MHz HE PPDU In 2.4 GHz subfield is 0. NOTE 3—If a non-AP STA operates with 20 MHz channel width and the 20 MHz In 160/80+80 MHz HE PPDU subfield is set to 0, then the 242-tone RU in a 160 MHz and 80+80 MHz HE MU PPDU in the 5 GHz band is not supported.
Punctured Preamble Rx	B0 indicates support for the reception of an 80 MHz preamble where the secondary 20 MHz subchannel is punctured. B1 indicates support for the reception of an 80 MHz preamble where one of the two 20 MHz subchannels in the secondary 40 MHz is punctured. B2 indicates support for the reception of a 160 MHz or 80+80 MHz preamble where in the primary 80 MHz of the preamble the secondary 20 MHz is punctured. B3 indicates support for the reception of a 160 MHz or 80+80 MHz preamble where in the primary 80 MHz of the preamble, the primary 40 MHz is present.	B0 is set to 0 if not supported. B0 set to 1 if supported. B1 set to 0 if not supported. B1 set to 1 if supported. B2 set to 0 if not supported. B2 set to 1 if supported. B3 set to 0 if not supported. B3 set to 1 if supported.
Device Class	For a non-AP STA, indicates whether the STA is a Class A or a Class B device. Reserved for an AP.	Set to 1 for a Class A device. Set to 0 for a Class B device.

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Table 9-262aa—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
LDPC Coding In Payload	Indicates support for the transmission and reception of LDPC encoded packets.	Set to 0 if not supported. Set to 1 if supported.
HE SU PPDU With 1x HE-LTF And 0.8 μs GI	Indicates support of the reception of an HE SU PPDU with 1x LTF and 0.8 μs guard interval duration.	Set to 0 if not supported. Set to 1 if supported.
Midamble Rx Max NSTS	When the Doppler Rx subfield is 1, indicates the maximum number of space-time streams supported for reception when midamble is used in the Data field.	Set to 0 for 1 space-time stream Set to 1 for 2 space-time streams Set to 2 for 3 space-time streams Set to 3 for 4 space-time streams NOTE—for an HE ER SU PPDU the values 2 and 3 are reserved.
NDP With 4x HE-LTF And 3.2 μs GI	For a beamformee, indicates support for receiving an NDP with 4x LTF and 3.2 μs guard interval duration.	If the SU Beamformee field is 1: Set to 0 if not supported. Set to 1 if supported.
STBC Tx ≤ 80 MHz	Indicates support for the transmission of an HE PPDU that has a bandwidth less than or equal to 80 MHz using STBC and with one spatial stream.	Set to 0 if not supported. Set to 1 if supported.
STBC Rx ≤ 80 MHz	Indicates support for the reception of an HE PPDU that has a bandwidth less than or equal to 80 MHz using STBC and with one spatial stream.	Set to 0 if not supported. Set to 1 if supported.
Doppler Tx	Indicates support for transmitting HE PPDUs with midamble.	Set to 0 if not supported. Set to 1 if supported.
Doppler Rx	Indicates support for receiving HE PPDUs with midamble.	Set to 0 if not supported. Set to 1 if supported.
Full Bandwidth UL MU-MIMO	For an AP, indicates support for MU-MIMO reception of an HE TB PPDU on an RU that spans the entire PPDU bandwidth (UL MU-MIMO). For a non-AP STA, indicates support for the transmission of an HE TB PPDU on an RU that spans the entire PPDU bandwidth (UL MU-MIMO).	Set to 0 if not supported. Set to 1 if supported.
Partial Bandwidth UL MU-MIMO	For an AP, indicates support for the reception of an HE TB PPDU on an RU that does not span the entire PPDU bandwidth (UL MU-MIMO with OFDMA). For a non-AP STA, indicates support for the transmission of an HE TB PPDU on an RU that does not span the entire PPDU bandwidth (UL MU-MIMO with OFDMA).	Set to 0 if not supported. Set to 1 if supported.
DCM Max Constellation Tx	Indicates the maximum supported constellation for DCM in the Data field of an HE TB PPDU that the STA is capable of transmitting.	B0-B1 signals the maximum constellation: 00: Does not support DCM 01: BPSK 10: QPSK 11: 16-QAM
DCM Max NSS Tx	Indicates the maximum number of spatial streams supported for transmission when DCM is used in the Data field of an HE TB PPDU.	Set to 0 for 1 spatial stream. Set to 1 for 2 spatial streams.

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Table 9-262aa—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
DCM Max Constellation Rx	Indicates the maximum supported constellation for DCM in both the Data field and HE-SIG-B field that the STA is capable of receiving.	B0-B1 signals the maximum constellation: 00: Does not support DCM 01: BPSK 10: QPSK 11: 16-QAM
DCM Max NSS Rx	Indicates the maximum number of spatial streams supported for reception when DCM is used in the Data field.	Set to 0 for 1 spatial stream. Set to 1 for 2 spatial streams.
Rx HE MU PPDU From Non-AP STA	Indicates support for the reception on an RU in an HE MU PPDU from a non-AP STA where one of the following apply: — The RU spans the entire PPDU bandwidth — The RU does not span the entire PPDU bandwidth (106-tone RU within 20 MHz bandwidth)	Set to 0 if not supported. Set to 1 if supported.
SU Beamformer	Indicates support for operation as an SU beamformer.	Set to 0 if not supported. Set to 1 if supported or if sent by an AP with support for 4 or more spatial streams.
SU Beamformee	Indicates support for operation as an SU beamformee.	For an AP: Set to 0 if not supported. Set to 1 if supported. Set to 1 for a non-AP STA.
MU Beamformer	Indicates support for operation as an MU beamformer.	For an AP: Set to 0 if not supported. Set to 1 if the SU Beamformer field is 1 and operation as an MU beamformer is supported. Set to 0 for a non-AP STA.
Beamformee STS ≤ 80 MHz	For bandwidth less than or equal to 80 MHz, it indicates the maximum number of space-time streams that the STA can receive in an HE NDP, the maximum value for $N_{STS,total}$ that can be sent in a DL MU-MIMO transmission on an RU where the RU may or may not span the entire PPDU bandwidth, that includes that STA. Reserved if the SU Beamformee field is 0.	If SU beamformee capable, set to the maximum number of space-time streams that the STA is capable of receiving in an HE NDP minus 1. The minimum value of this field is 3.
Beamformee STS > 80 MHz	For bandwidths greater than 80 MHz, it indicates the maximum number of space-time streams that the STA can receive in an HE NDP, the maximum value for $N_{STS,total}$ that can be sent in a DL MU-MIMO transmission on an RU where the RU may or may not span the entire PPDU bandwidth, that includes that STA. Reserved if the SU Beamformee field is 0.	If SU beamformee capable, set to the maximum number of space-time streams that the STA is capable of receiving in an HE NDP minus 1. The minimum value of this field is 3.

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Table 9-262aa—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
Number Of Sounding Dimensions ≤ 80 MHz	For bandwidth less than or equal to 80 MHz, it indicates the beamformer's capability indicating the maximum value of the TXVECTOR parameter NUM_STS for an HE NDP. Reserved if the SU Beamformee field is 0.	If SU beamformer capable, set to the maximum supported value of the TXVECTOR parameter NUM_STS minus 1.
Number Of Sounding Dimensions > 80 MHz	For bandwidth greater than 80 MHz, it indicates the beamformer's capability indicating the maximum value of the TXVECTOR parameter NUM_STS for an HE NDP. Reserved if the SU Beamformee field is 0.	If SU beamformer capable, set to the maximum supported value of the TXVECTOR parameter NUM_STS minus 1.
Ng = 16 SU Feedback	Indicates HE beamformee support for a tone grouping of 16 in the HE Compressed Beamforming Report field for SU-type feedback.	Set to 0 if not supported. Set to 1 if supported.
Ng = 16 MU Feedback	Indicates HE beamformee support for a tone grouping of 16 in the HE Compressed Beamforming Report field for MU-type feedback.	Set to 0 if not supported. Set to 1 if supported.
Codebook Size (ϕ, ψ) = {4, 2} SU Feedback	Indicates HE beamformee support for a codebook size (ϕ, ψ) = {4, 2} in the HE Compressed Beamforming Report field for SU-type feedback.	Set to 0 if not supported. Set to 1 if supported.
Codebook Size (ϕ, ψ) = {7, 5} MU Feedback	Indicates HE beamformee support for a codebook size (ϕ, ψ) = {7, 5} in the HE Compressed Beamforming Report field for MU-type feedback.	Set to 0 if not supported. Set to 1 if supported.
Triggered SU Beamforming Feedback	For an AP, indicates support for the reception of partial and full bandwidth SU-type feedback. For a non-AP STA, indicates support for the transmission of partial and full bandwidth SU-type feedback.	Set to 0 if not supported. Set to 1 if supported.
Triggered MU Beamforming Feedback	For an AP, indicates support for the reception of partial bandwidth MU-type feedback. For a non-AP STA, indicates support for the transmission of partial bandwidth MU-type feedback.	Set to 0 if not supported. Set to 1 if supported.
Triggered CQI Feedback	For an AP, indicates support for the reception of partial and full bandwidth CQI-only feedback. For a non-AP STA, indicates support for the transmission of partial and full bandwidth CQI-only feedback.	Set to 0 if not supported. Set to 1 if supported.
Partial Bandwidth Extended Range	Indicates support for the transmission and reception of the Data field of the HE ER SU PPDU when transmitted over the high frequency 106-tone RU within primary 20 MHz channel.	Set to 0 if not supported. Set to 1 if supported.
Partial Bandwidth DL MU-MIMO	For a non-AP STA, indicates support for the reception of a DL MU-MIMO transmission on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth (DL MU-MIMO with OFDMA). Reserved for an AP.	Set to 0 if not supported. Set to 1 if supported. NOTE—If the non-AP STA sets this field to 0, it shall support receiving SU RU within an HE MU PPDU where some other RU is employing DL MU-MIMO.

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Table 9-262aa—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
PPE Threshold Present	Indicates whether or not the PPE Threshold field is present.	Set to 1 if PPE Threshold field is present. Set to 0, otherwise
SRP-based SR Support	Indicates support for SRP-based SR operation.	Set to 0 if not supported. Set to 1 if supported.
Power Boost Factor α_r Support	Indicates that the STA supports a power boost factor α_r for the *r*-th RU in the range [0.5, 2].	Set to 0 if not supported. Set to 1 if supported.
HE SU PPDU And HE MU PPDU With 4x HE-LTF And 0.8 μs GI	Indicates support for the reception of an HE SU PPDU and HE MU PPDU with 4x LTF and 0.8 μs guard interval duration.	Set to 0 if not supported. Set to 1 if supported. This subfield is set to 1 if the HE ER SU PPDU With 4x HE-LTF And 0.8 μs GI subfield is 1.
Max Nc	For a transmitting STA acting as a beamformee, it indicates the maximum Nc for beamforming sounding feedback supported.	If SU beamformee capable, then set to the maximum Nc for beamforming sounding feedback minus 1. Otherwise, reserved.
STBC Tx > 80 MHz	Indicates support for the transmission of an HE PPDU that has a bandwidth greater than 80 MHz and is using STBC with one spatial stream.	Set to 0 if not supported. Set to 1 if supported.
STBC Rx > 80 MHz	Indicates support for the reception of an HE PPDU that has a bandwidth greater than 80 MHz and is using STBC with one spatial stream.	Set to 0 if not supported. Set to 1 if supported.
HE ER SU PPDU With 4x HE-LTF And 0.8 μs GI	Indicates support for the reception of an HE ER SU PPDU with 4x LTF and 0.8 μs guard interval duration.	Set to 0 if not supported. Set to 1 if supported.
20 MHz In 40 MHz HE PPDU In 2.4 GHz Band	Indicates support of 26-, 52-, and 106-tone mapping for a 20 MHz operating non-AP HE STA that is the receiver of a 40 MHz HE MU PPDU in 2.4 GHz band, or the transmitter of a 40 MHz HE TB PPDU in 2.4 GHz band. Reserved for an AP.	Set to 0 if not supported. Set to 1 if supported. NOTE—Set to 1 if B0 of Channel Width Set subfield is set to 1.
20 MHz In 160/ 80+80 MHz HE PPDU	Indicates support of 26-, 52-, and 106-tone mapping for a 20 MHz operating non-AP HE STA that is the receiver of a 80+80 MHz or a 160 MHz HE MU PPDU, or the transmitter of a 80+80 MHz or 160 MHz HE TB PPDU. Reserved for an AP.	Set to 0 if not supported. Set to 1 if supported. NOTE—Set to 1 if B2 of Channel Width Set subfield is set to 1.
80 MHz In 160/ 80+80 MHz HE PPDU	Indicates supports of 160 MHz OFDMA for a non-AP HE STA that sets bit B1 of Channel Width Set to 1, and sets B2 and B3 of Channel Width Set each to 0, when operating with 80 MHz channel width. The capability bit is applicable while receiving a 80+80 MHz or a 160 MHz HE MU PPDU, or transmitting a 80+80 MHz or a 160 MHz HE TB PPDU. Reserved for an AP.	Set to 0 if not supported. Set to 1 if supported. NOTE—Set to 1 if B2 of Channel Width Set subfield is set to 1.

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Table 9-262aa—Subfields of the HE PHY Capabilities Information field *(continued)*

Subfield	Definition	Encoding
HE ER SU PPDU With 1x HE-LTF And 0.8 μs GI	Indicates support of the reception of an HE ER SU PPDU with 1x LTF and 0.8 μs guard interval duration.	Set to 0 if not supported. Set to 1 if supported.
Midamble Rx 2x And 1x HE-LTF	When the Doppler Rx subfield is 1, indicates support for receiving midambles with 2x HE-LTF, 1x HE-LTF in HE SU PPDU if the HE SU PPDU With 1x HE-LTF And 0.8 μs GI subfield is set to 1, and 1x HE-LTF in HE ER SU PPDU if the HE ER SU PPDU With 1x HE-LTF And 0.8 μs GI subfield is set to 1.	Set to 0 if not supported. Set to 1 if supported.

9.4.2.237.4 Supported HE-MCS And NSS Set field

The Supported HE-MCS And NSS Set field is used to convey the combinations of HE-MCSs and spatial streams that a STA supports for reception and the combinations that it supports for transmission. The structure of the field is shown in Figure 9-589cm (Supported HE-MCS And NSS Set field format).

	Rx HE-MCS Map ≤ 80 MHz	Tx HE-MCS Map ≤ 80 MHz	Rx HE-MCS Map 160 MHz	Tx HE-MCS Map 160 MHz	Rx HE-MCS Map 80+80 MHz	Rx HE-MCS Map 80+80 MHz
Octets:	2	2	0 or 2	0 or 2	0 or 2	0 or 2

Figure 9-589cm—Supported HE-MCS And NSS Set field format

The subfields of the Supported HE-MCS And NSS Set field, and their presence, are defined in Table 9-262ab (Subfields of the Supported HE-MCS And NSS Set field).

Table 9-262ab—Subfields of the Supported HE-MCS And NSS Set field

Subfield	Definition	Encoding
Rx HE-MCS Map ≤ 80 MHz	Indicates the maximum value of the RXVECTOR parameter MCS of a PPDU that can be received at all channel widths less than or equal to 80 MHz supported by this STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-589cm (Supported HE-MCS And NSS Set field format) and the associated description. The Rx HE-MCS Map ≤ 80 MHz subfield is always present in the Supported HE-MCS And NSS Set field.
Tx HE-MCS Map ≤ 80 MHz	Indicates the maximum value of the TXVECTOR parameter MCS of a PPDU that can be transmitted at all channel widths less than or equal to 80 MHz supported by this STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-589cm (Supported HE-MCS And NSS Set field format) and the associated description. The Tx HE-MCS Map ≤ 80 MHz subfield is always present in the Supported HE-MCS And NSS Set field.

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Table 9-262ab—Subfields of the Supported HE-MCS And NSS Set field *(continued)*

Rx HE-MCS Map 160 MHz	Indicates the maximum value of the RXVECTOR parameter MCS of a PPDU that can be received at 160 MHz channel width supported by this STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-589cm (Supported HE-MCS And NSS Set field format) and the associated description. The Rx HE-MCS Map 160 MHz subfield is present if B2 of the Channel Width Set subfield of the HE PHY Capabilities Information field is set to 1; otherwise, it is not present.
Tx HE-MCS Map 160 MHz	Indicates the maximum value of the TXVECTOR parameter MCS of a PPDU that can be transmitted at 160 MHz channel width supported by this STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-589cm (Supported HE-MCS And NSS Set field format) and the associated description. The Tx HE-MCS Map 160 MHz subfield is present if B2 of the Channel Width Set subfield of the HE PHY Capabilities Information field is set to 1; otherwise, it is not present.
Rx HE-MCS Map 80+80 MHz	Indicates the maximum value of the RXVECTOR parameter MCS of a PPDU that can be received at 80+80 MHz channel width supported by this STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-589cm (Supported HE-MCS And NSS Set field format) and the associated description. The Rx HE-MCS Map 80+80 MHz subfield is present if B3 of the Channel Width Set subfield of the HE PHY Capabilities Information field is set to 1; otherwise, it is not present.
Tx HE-MCS Map 80+80 MHz	Indicates the maximum value of the TXVECTOR parameter MCS of a PPDU that can be transmitted at 80+80 MHz channel width supported by this STA for each number of spatial streams.	The format and encoding of this subfield are defined in FFigure 9-589cm (Supported HE-MCS And NSS Set field format) and the associated description. The Tx HE-MCS Map 80+80 MHz subfield is present if B3 of the Channel Width Set subfield of the HE PHY Capabilities Information field is set to 1; otherwise, it is not present.

Each Rx HE-MCS Map subfield and each Tx HE-MCS Map subfield have the structure shown in Figure 9-589cn (Rx HE-MCS Map and Tx HE-MCS Map subfields and Basic HE-MCS And NSS Set field).

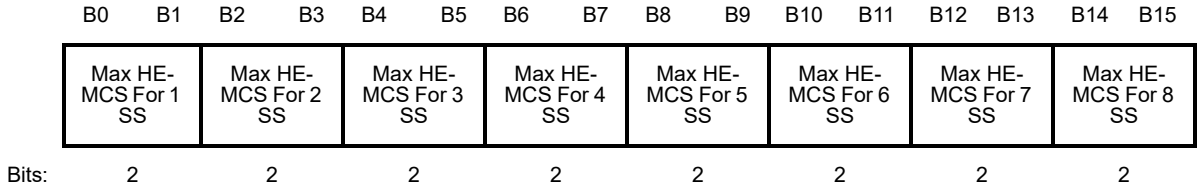


Figure 9-589cn—Rx HE-MCS Map and Tx HE-MCS Map subfields and Basic HE-MCS And NSS Set field

The Max HE-MCS For *n* SS subfield (where *n* = 1, ..., 8) is encoded as follows:

— 0 indicates support for HE-MCS 0-7 for *n* spatial streams

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— 1 indicates support for HE-MCS 0-9 for *n* spatial streams

— 2 indicates support for HE-MCS 0-11 for *n* spatial streams

— 3 indicates that *n* spatial streams is not supported for HE PPDUs

The maximum HE NSS in receive for a given MCS is equal to the smaller of:

— The maximum value of *n* for which the Max HE-MCS For *n* SS has a value that indicates support for that MCS (0, 1, or 2 for MCS 0-7, 1 or 2 for MCS 8-9, 2 for MCS 10-11)

— The maximum supported NSS as indicated by the value of the Rx NSS field of the Operating Mode Notification frame if the value of Rx NSS Type is 0 or of the OM Control field

NOTE—An HE-MCS indicated as supported in the Rx HE-MCS Map fields for a particular number of spatial streams might not be valid at all bandwidths (see 28.5 (Parameters for HE-MCSs)) and might be affected by 27.15.4.3 (Additional rate selection constraints for HE PPDUs).

The maximum HE NSS in transmit for a given MCS is equal to the smaller of:

— The maximum value of *n* for which the Max HE-MCS For *n* SS has a value that indicates support for that MCS (0, 1, or 2 for MCS 0-7, 1 or 2 for MCS 8-9, 2 for MCS 10-11)

— The maximum supported NSTS as indicated by the value of the Tx NSTS field of the OM Control field sent by a non-AP STA

NOTE—An HE-MCS indicated as supported in the Tx HE-MCS Map fields for a particular number of space-time streams might not be valid at all bandwidths (see 28.5 (Parameters for HE-MCSs)) and might be affected by 27.15.4.3 (Additional rate selection constraints for HE PPDUs).

9.4.2.237.5 PPE Thresholds field

The PPE Thresholds field is used to determine the minimal packet extension value (see 28.3.12 (Packet extension)) for an HE PPDU of a particular RU allocation size and NSS value. The format of the PPE Thresholds field is defined in Figure 9-589co (PPE Thresholds field format).

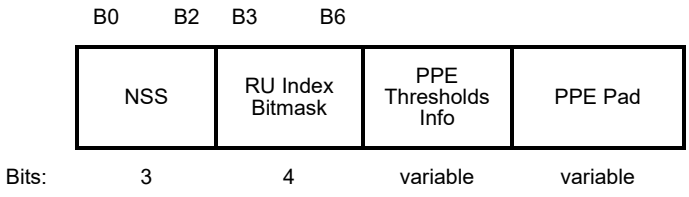


Figure 9-589co—PPE Thresholds field format

The NSS subfield contains an unsigned integer that is equal to the number of NSS values minus 1 for which PPE threshold values are included in the PPE Thresholds Info subfield.

The RU Index Bitmask subfield contains a bitmask that indicates whether PPE threshold values are present for each of four RU allocation sizes according to their RU allocation index values (see Table 9-262ad (RU allocation index)). For example, when B3 is set to 1, PPE threshold values are present for the RU allocation corresponding to RU allocation index 0 and when B3 is set to 0, PPE threshold values are not present for the RU allocation corresponding to RU allocation index being 0.

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The PPE Thresholds Info field contains 6 × (NSS + 1) bits for every bit in the RU Index Bitmask subfield that is nonzero. The format of the PPE Thresholds Info field is defined in Figure 9-589cp (PPE Thresholds Info field format).

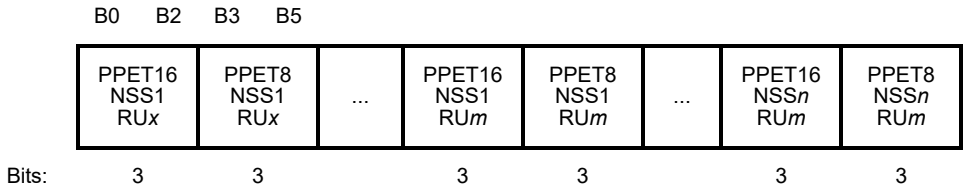


Figure 9-589cp—PPE Thresholds Info field format

The PPET16 and PPET8 subfields for various NSS and RU values appear in increasing NSS value and increasing RU index value order. Lower numbered PPE Thresholds Info field bits contain PPET16 and PPET8 subfields corresponding to lower numbered NSS values. Within a set of PPET16 and PPET8 subfields corresponding to a single value of NSS, lower numbered PPE Thresholds Info field bits contain PPET16 and PPET8 subfields corresponding to lower numbered RU index values. The PPET16 NSS*n* RU*b* and PPET8 NSS*n* RU*b* subfields are present for all values of *n* and *b* where $1 \le n \le (\text{NSS} + 1)$ and where $b = [x, \ldots, m]$ is the set of integers equal to the ordered list of bit positions of all bits that are set to 1 in the RU Index Bitmask subfield, with *x* being the lowest value.

Each PPET8 NSS*n* RU*b* and PPET16 NSS*n* RU*b* subfield contains an integer that corresponds to a constellation index value related to the minimal transmission constellation of an HE PPDU as defined in Table 9-262ac (Constellation index).

Table 9-262ac—Constellation index

Constellation Index	Corresponding Transmission Constellation
0	BPSK
1	QPSK
2	16-QAM
3	64-QAM
4	256-QAM
5	1024-QAM
6	Reserved
7	None

The value of the PPET8 NSS*n* RU*m* subfield is always less than the value of the PPET16 NSS*n* RU*m* subfield, except when the PPET8 subfield is 7.

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The RU allocation index for each RU allocation size is defined in Table 9-262ad (RU allocation index).

Table 9-262ad—RU allocation index

RU allocation index	RU allocation size
0	242
1	484
2	996
3	2×996

The PPE Pad field contains all zeros. The number of bits in the PPE Pad field is the number of bits required to round the length of the PPE Thresholds Info field up to the next integer number of octets.

9.4.2.238 HE Operation element

The operation of HE STAs in an HE BSS is controlled by the HT Operation element, the VHT Operation element and the HE Operation element. The format of the HE Operation element is defined in Figure 9-589cq (HE Operation element format).

	Element ID	Length	Element ID Extension	HE Operation Parameters	Basic HE-MCS And NSS Set	VHT Operation Information	MaxBSSID Indicator
Octets:	1	1	1	4	2	0 or 3	0 or 1

Figure 9-589cq—HE Operation element format

The Element ID, Length, and Element ID Extension fields are defined in 9.4.2.1 (General).

The format of the HE Operation Parameters field is defined in Figure 9-589cr (HE Operation Parameters field format).

	B0 B5	B6 B8	B9	B10 B19	B20	B21	B22 B27	B28	B29	B30	B31
	BSS Color	Default PE Duration	TWT Required	TXOP Duration RTS Threshold	Partial BSS Color	VHT Operation Information Present	Reserved	Multiple BSSID AP	Tx BSSID Indicator	BSS Color Disabled	Reserved
Bits:	6	3	1	10	1	1	6	1	1	1	1

Figure 9-589cr—HE Operation Parameters field format

The BSS Color subfield is an unsigned integer whose value is the BSS Color of the BSS corresponding to the AP, IBSS STA, mesh STA or TDLS STA that transmitted this element and is set as defined in 27.11.4 (BSS_COLOR).

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The Default PE Duration subfield indicates the Packet Extension (PE) field duration in units of 4 μs for an HE TB PPDU that is solicited with an UMRS Control subfield and is used as defined in 27.5.3.3 (STA behavior for UL MU operation). Values 5-7 of the Default PE Duration subfield are reserved.

The TWT Required subfield is set to 1 to indicate that the AP requires its associated non-AP HE STAs to operate in the role of either TWT requesting STA, as described 27.7.2 (Individual TWT agreements), or TWT scheduled STA, as described in 27.7.3 (Broadcast TWT operation) and set to 0 otherwise.

The TXOP Duration RTS Threshold subfield enables an HE AP to manage RTS/CTS usage by non-AP HE STAs that are associated with it (see 27.2.1 (TXOP duration-based RTS/CTS)). The TXOP Duration RTS Threshold subfield contains the TXOP duration RTS threshold in units of 32 μs, which enables the use of RTS/CTS except for the value 1023. The value 1023 indicates that TXOP duration-based RTS is disabled.

The Partial BSS Color subfield is set to 1 to indicate that an AID assignment rule based on the BSS color as defined in 27.16.3 (AID assignment) is applied for the BSS. Otherwise, the Partial BSS Color subfield is set to 0.

The VHT Operation Information Present field is set to 1 to indicate that the VHT Operation Information field is present in the HE Operation element and set to 0 otherwise. The field is set to 0 if the frame containing this element also contains a VHT Operation element.

The Multiple BSSID AP field is set to 1 to indicate that the AP transmitting this element belongs to a Multiple BSSID set and is set to 0 otherwise. A TDLS STA, IBSS STA or mesh STA transmitting this element sets the field to 0.

The Tx BSSID Indicator field indicates whether an HE AP corresponds to a transmitted BSSID. An HE AP corresponding to a nontransmitted BSSID sets the Tx BSSID Indicator field to 0. An HE AP corresponding to a transmitted BSSID sets Tx BSSID Indicator field to 1. The TxBSSID Indicator field is reserved when the Multiple BSSID AP field is 0.

An HE AP sets the BSS Color Disabled subfield to 1 if the HE AP decides to disable the use of the BSS color for the BSS that it serves, for example, after detecting a BSS Color overlap in the neighborhood as described in 27.11.4 (BSS_COLOR); otherwise the HE AP sets the BSS Color Disabled subfield to 0.

The Basic HE-MCS And NSS Set field indicates the HE-MCSs for each number of spatial streams in HE PPDUs that are supported by all HE STAs in the BSS (including IBSS and MBSS) in transmit and receive. The Basic HE-MCS And NSS Set field is defined in Figure 9-589cn (Rx HE-MCS Map and Tx HE-MCS Map subfields and Basic HE-MCS And NSS Set field).

The structure of the VHT Operation Information field is defined in Figure 9-564 (VHT Operation Information field) and its subfields are defined in Table 9-252 (VHT Operation Information subfields). The VHT Operation Information field is present if the VHT Operation Info Present field is 1; otherwise not present.

The MaxBSSID Indicator field is set to the same value as the MaxBSSID Indicator field carried in the Multiple BSSID element (see 9.4.2.46 (Multiple BSSID element)) advertised by the transmitted BSSID. This field is present if the Multiple BSSID AP subfield is 1 in HE Operation Parameters field and is not present otherwise.

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9.4.2.239 UL OFDMA-based Random Access (UORA) Parameter Set element

The metrics of the OFDMA-based random access mechanism (see 27.5.5 (UL OFDMA-based random access (UORA))) are signaled in the UORA Parameter Set element. The format of the UORA Parameter Set element is defined in Figure 9-589cs (UORA Parameter Set element format).

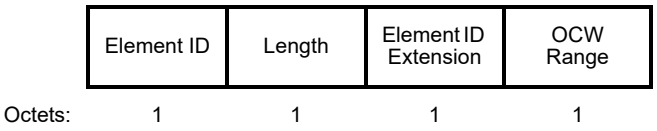


Figure 9-589cs—UORA Parameter Set element format

The Element ID, Length, Element ID Extension fields are defined in 9.4.2.1 (General).

The OCW Range field indicates the minimum and maximum values of the OCW (OFDMA contention window) derived from the fields defined in Figure 9-589ct (OCW Range field format).

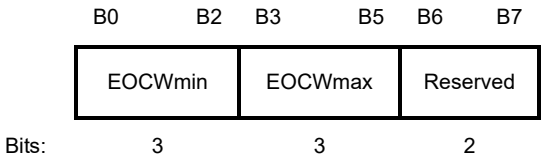


Figure 9-589ct—OCW Range field format

The EOCWmin field indicates the minimum value of OCW for the initial HE TB PPDU transmission using UL OFDMA-based random access. The OCWmin parameter is used by a STA either for an initial transmission or following a successful HE TB PPDU transmission and is derived from the value in the EOCWmin field as

$$OCWmin = 2^{EOCWmin} - 1$$

The EOCWmax field indicates the maximum value of OCW for UL OFDMA-based random access. The OCWmax parameter used by a STA for its retransmission attempts of UL OFDMA-based random access is derived from the value in the EOCWmax field as

$$OCWmax = 2^{EOCWmax} - 1$$

9.4.2.240 MU EDCA Parameter Set element

The format of the MU EDCA Parameter Set element is defined in Figure 9-589cu (MU EDCA Parameter Set element).

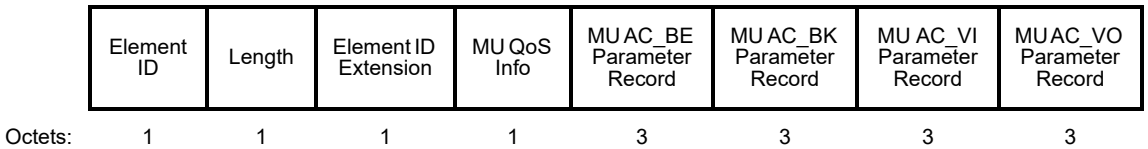


Figure 9-589cu—MU EDCA Parameter Set element

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The Element ID, Length, and Element ID Extension fields are defined in 9.4.2.1 (General).

For an infrastructure BSS, the MU EDCA Parameter Set element is used by an AP to control the EDCA from HE non-AP STAs as defined in 27.2.6 (Obtaining an EDCA TXOP for HE non-AP STAs using MU EDCA parameters). The most recent MU EDCA Parameter Set element received by a non-AP HE STA is used to update the appropriate MIB values.

The format of the MU QoS Info field is the same as the QoS Info field defined in 9.4.1.17 (QoS Info field) when sent by the AP. The MU QoS Info field contains the EDCA Parameter Set Update Count subfield, which is initially set to 0 and is incremented each time any of the MU AC parameters changes. This subfield is used by a non-AP HE STA to determine whether the MU EDCA parameter set has changed and requires updating the appropriate MIB attributes.

The format of the MU AC_BE, MU AC_BK, MU AC_VI, and MU AC_VO Parameter Record fields are identical and defined in Figure 9-589cv (MU AC Parameter Record field format).

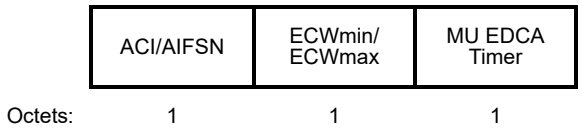


Figure 9-589cv—MU AC Parameter Record field format

The format of the ACI/AIFSN field is defined in Figure 9-262 (ACI/AIFSN field) and the encoding of its subfields is defined in 9.4.2.29 (EDCA Parameter Set element), except that a value 0 of the AIFSN field indicates that the AIFSN is equal to the value of the MU EDCA Timer, i.e., EDCA is disabled for the duration specified by the MUEDCATimer for the corresponding AC.

The format of the ECWmin/ECWmax field is defined in Figure 9-263 (ECWmin and ECWmax fields) and the encoding of its subfields is defined in 9.4.2.29 (EDCA Parameter Set element).

The MU EDCA Timer field indicates the duration of time, in units of 8 TUs, during which the HE STA uses the MU EDCA parameters for the corresponding AC, as defined in 27.2.6 (Obtaining an EDCA TXOP for HE non-AP STAs using MU EDCA parameters).

9.4.2.241 BSS Color Change Announcement element

The BSS Color Change Announcement element is used by an HE AP to advertise a BSS Color change and the value of the new BSS color. The format of the BSS Color Change Announcement element is shown in Figure 9-589cw (BSS Color Change Announcement element format).

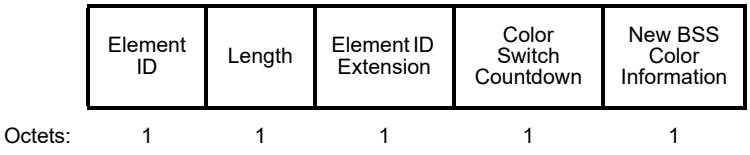


Figure 9-589cw—BSS Color Change Announcement element format

The Element ID, Length, and Element ID Extension fields are defined in 9.4.2.1 (General).

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The Color Switch Countdown field is set to the number of TBTTs that remain until the HE AP sending the BSS Color Change Announcement element switches to the new BSS color. A value of 0 indicates that the switch occurs at the current TBTT if the element is carried in a Beacon frame or the next TBTT following the frame that carried the element if the frame is not a Beacon frame.

The format of the New BSS Color Information field is defined in Figure 9-589cx (New BSS Color Information field format). The New BSS Color subfield is set to the new BSS color value that the HE AP intends to use starting from the TBTT at which the color switch countdown reaches 0.



Figure 9-589cx—New BSS Color Information field format

The BSS Color Change Announcement element is carried in the HE BSS Color Change Announcement frame and is optionally included in Beacon, Probe Response, and (Re)Association Response frames. The use of the BSS Color Change Announcement element and HE BSS Color Change Announcement frame is described in 27.16.2.1 (Selecting and advertising a new BSS color).

9.4.2.242 Quiet Time Period element

9.4.2.242.1 General

Quiet Time Period Action frame formats are defined to support quiet time Period functionality for peer-to-peer (Table 9-421ab) operation. This element is carried in Quiet Time Period Action frame (see 9.6.30 (Quiet Time Period Action frame details)) A Control field (Figure 9-589cy (Quiet Time Period element format)), in the octet immediately after the Quiet Time Period field, specifies the type of actions of the Quiet Time Period action frame. The first two-bits defines the value and referred to as Quiet Time Period Subtype field. The remaining 6 bits are reserved.

The format of the Quiet Time Period element is shown in Figure 9-589cy (Quiet Time Period element format).

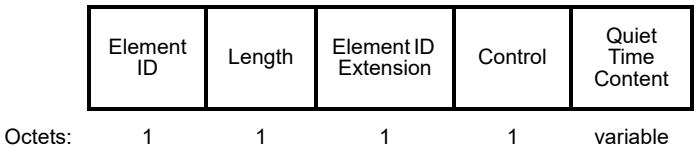


Figure 9-589cy—Quiet Time Period element format

The Element ID, Length, and Element ID Extension fields are defined in 9.4.2.1 (General).

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A one octet Control field specifies the type of the Quiet Time Period element. The first two-bits defines the value and are referred to as Quiet Time Period Subtype field. The remaining 6 bits are reserved. Table 9-262ae (Control field encoding) shows the encoding of the Control field.

Table 9-262ae—Control field encoding

Control field value	Meaning
0	Quiet Time Period Setup
1	Quiet Time Period Request
2	Quiet Time Period Response
3-255	Reserved

Quiet Time Content field is a variable length field and carries information of quiet time operation indicated by the value in the Control field.

9.4.2.242.2 Quiet Time Period Setup

The Quiet Time Period Setup subtype defines a period for a peer-to-peer operation (see 27.16.4 (Quiet HE STAs in an HE BSS)). The quiet time period can be used by an AP to mitigate the interference by reducing the contention from HE STAs in a period that gives preference to HE STAs participating in peer-to-peer operation.

The content of the Quiet Time Content subfield in the Quiet Time Period Setup subtype is shown Figure 9-589cz (Quiet Time Content subfield format in Quiet Time Period Setup subtype).

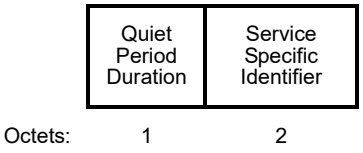


Figure 9-589cz—Quiet Time Content subfield format in Quiet Time Period Setup subtype

The Quiet Period Duration field is set to the duration of the quiet time period, in units of 32 μs, that is no larger than the value indicated in the Quiet Period Interval subtype field of the Quiet Time Period Request subtype sent by the requester HE STA.

The Service Specific Identifier field indicates a specified peer-to-peer operation, and the HE STA supporting it can transmit frames. Value for the Service Specific Identifier field contains an identifier assigned by the peer-to-peer operation.

9.4.2.242.3 Quiet Time Period Request

The Quiet Time Period Request subtype defines a periodic sequence of quiet time periods that the requester HE STA requests the responder HE AP to schedule.

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The content of the Quiet Time Content subfield in the Quiet Time Period Request subtype is shown Figure 9-589da (Quiet Time Content subfield format in Quiet Time Period Request subtype).



Figure 9-589da—Quiet Time Content subfield format in Quiet Time Period Request subtype

The Dialog Token field is used to identify the Quiet Time Period Response subtype to which the Quiet Time Period Request subtype corresponds.

The Quiet Period Offset field is set to the offset of the first quiet time period from the TBTT expressed in TUs.

The Quiet Period Interval field is set to the requested interval between the start of two consecutive quiet time periods, expressed in TUs.

The Quiet Period Duration field is Duration field is a one byte field with resolution of 32 μs.

The Repetition Count field is set to the number of requested quiet time periods. Repetition count equal to 0 indicated the setup of the quiet time period is for one time operation. Repetition count equals to 0xFF indicated the setup of the quiet time period is cancelled.

The Service Specific Identifier field indicates a specified peer-to-peer operation, and the HE STA supporting it can transmit frames. The Service Specific Identifier field indicates HE STAs participated in the peer-to-peer operation is given preference to transmit frames in the period. The Service Specific Identifier ID field contains an identifier assigned by the peer-to-peer applications.

9.4.2.242.4 Quiet Time Period Response

The Quiet Period Response subtype defines the feedback information from the AP that received the Quiet Time Period Request element. If an AP decides to counter the request, the AP can set different values carried in the Quiet Period Response frame.

The content of Quiet Time Content subfield in the Quiet Time Period Response subtype is shown in Figure 9-589db (Quiet Time Content subfield format in Quiet Time Period Response subtype).

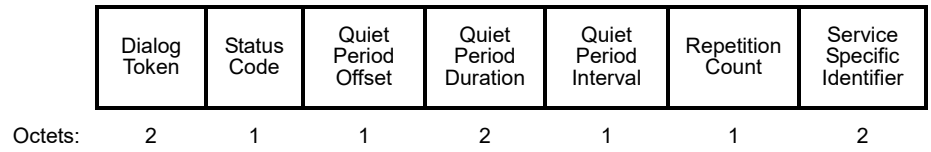


Figure 9-589db—Quiet Time Content subfield format in Quiet Time Period Response subtype

The Control field of values 2 indicate the Quiet Time Content is for Quiet Time Period Response operation.

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The Dialog Token field is used to identify Quiet Time Period Request subtype to which this Quiet Time Period Response subtype corresponds.

The Status Code field indicates the status of a requested operation. The value of the status code is shown in Table 9-262af (Status Code)

Table 9-262af—Status Code

Value	Meaning
0	Success
1	Reject
2	Counter
3-255	Reserved

The Quiet Period Offset field is set to the offset of the start of the first quiet time period from the transmission time of the preamble of the PPDU that contains the Quiet Time Period Response subtype, expressed in TUs. The reference time is the start of the preamble of the PPDU that contains this element.

The Quiet Period Interval field is set to the interval between the start of two consecutive quiet time periods, expressed in TUs.

The Quiet Period Duration field is a one octet field with resolution of 32 μs.

The Repetition Count field is set to the number of requested quiet time periods.

The Service Specific Identifier field indicates a peer-to-peer operation, and the HE STA supporting it can transmit frames. The Service Specific Identifier field contains an identifier assigned by the peer-to-peer applications.

9.4.2.243 Spatial Reuse Parameter Set element

The Spatial Reuse Parameter Set element provides information needed by STAs when performing OBSS_PD-based spatial reuse as defined in 27.9.2 (OBSS_PD-based spatial reuse operation). The format of the Spatial Reuse Parameter Set element is defined in Figure 9-589dc (Spatial Reuse Parameter Set element).

	Element ID	Length	Element ID Extension	SR Control	Non-SRG OBSS PD Max Offset	SRG OBSS PD Min Offset	SRG OBSS PD Max Offset	SRG BSS Color Bitmap	SRG Partial BSSID Bitmap
Octets:	1	1	1	1	0 or 1	0 or 1	0 or 1	0 or 8	0 or 8

Figure 9-589dc—Spatial Reuse Parameter Set element

The Element ID, Element ID extension and Length fields are defined in 9.4.2.1 (General).

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The SR Control field is defined in Figure 9-589dd (SR Control field format).

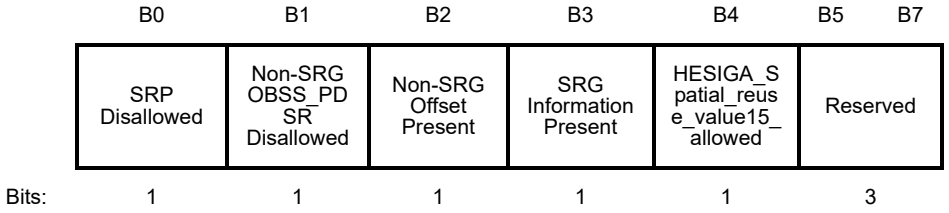


Figure 9-589dd—SR Control field format

The SRP Disallowed subfield in the SR Control field indicates whether SRP-based SR transmissions are allowed or not at non-AP STAs that are associated with the AP that transmitted this element. SRP-based SR transmissions are disallowed when the SRP Disallowed subfield has the value 1. SRP-based SR transmissions are allowed when the SRP Disallowed subfield has the value 0.

The Non-SRG OBSS_PD SR Disallowed subfield in the SR Control field indicates whether non-SRG OBSS_PD SR transmissions are allowed or not at non-AP STAs that are associated with the AP that transmitted this element. Non-SRG OBSS_PD SR transmissions are disallowed when the Non-OBSS_PD SR Disallowed subfield has the value 1. Non-SRG OBSS_PD SR transmissions are allowed when the Non-SRG OBSS_PD SR Disallowed subfield has the value 0.

The Non-SRG Offset Present subfield indicates whether the Non-SRG OBSS PD Max Offset subfield is present in the element. When this bit is set to 1, the Non-SRG OBSS PD Max Offset subfield is present. When this bit is set to 0, the Non-SRG OBSS PD Max Offset subfield is not present.

The SRG Information Present subfield indicates whether the SRG OBSS PD MIN Offset, SRG OBSS PD Max Offset, SRG BSS Color Bitmap and SRG Partial BSSID Bitmap subfields are present in the element. When this bit is set to 1, the SRG OBSS PD Min Offset, SRG OBSS PD Max Offset, SRG BSS Color Bitmap and SRG Partial BSSID Bitmap subfields are present. When this bit is set to 0, the SRG OBSS PD Min Offset, SRG OBSS PD Max Offset, SRG BSS Color Bitmap and SRG Partial BSSID Bitmap subfields are not present.

The HESIGA_Spatial_reuse_value15_allowed subfield in the SR Control field indicates whether non-AP STAs that are associated with the AP that transmitted this element may set the TXVECTOR parameter SPATIAL_REUSE to SRP_AND_NON-SRG-OBSS-PD_PROHIBITED SRP-based SR transmissions.

The Non-SRG OBSS PD Max Offset subfield is present when the value of the Non-SRG Offset Present subfield is equal to 1; otherwise the Non-SRG OBSS PD Max Offset subfield is not present. The Non-SRG OBSS PD Max Offset field contains an unsigned integer which is added to the value −82 dBm to generate the value of the Non-SRG OBSS PD Max parameter.

The SRG OBSS PD Min Offset subfield is present when the value of the SRG Information Present subfield is equal to 1; Otherwise the SRG OBSS PD Min Offset subfield is not present. The SRG OBSS PD Min Offset field contains an unsigned integer which is added to the value −82 dBm to generate the value of the SRG OBSS PD Min parameter.

The SRG OBSS PD Max Offset subfield is present when the value of the SRG Information Present subfield is equal to 1; Otherwise the SRG OBSS PD MAX Offset subfield is not present. The SRG OBSS PD MAX Offset field contains an unsigned integer which is added to the value −82 dBm to generate the value of the SRG OBSS PD Max parameter.

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The SRG BSS Color Bitmap subfield is present when the value of the SRG Information Present subfield is equal to 1; Otherwise the SRG BSS Color Bitmap subfield is not present. The SRG BSS Color Bitmap subfield is a bitmap that indicates which BSS Color values are used by members of the SRG of which the transmitting STA is a member. Each bit of the bitmap corresponds to one of the 63 available BSS Colors, where the lowest numbered bit corresponds to BSS Color value 0 and the highest numbered bit corresponds to BSS Color value 63. A BSS Color value is used by at least one BSS that is a member of the same SRG of the transmitting STA if the corresponding bit of the bitmap is set to 1. If a bit in the bitmap is set to 0, then no BSS in the same SRG of the transmitting STA uses the corresponding BSS Color value.

The SRG Partial BSSID Bitmap subfield is present when the value of the SRG Information Present subfield is equal to 1; otherwise the SRG Partial BSSID Bitmap subfield is not present. The SRG Partial BSSID Bitmap subfield is a bitmap that indicates which Partial BSSID values are used by members of the SRG of which the transmitting STA is a member. Each bit of the bitmap corresponds to one of the 2^6 possible values of BSSID[39:44], where the lowest numbered bit corresponds to Partial BSSID value 0 and the highest numbered bit corresponds to Partial BSSID value 63. A Partial BSSID value is used by at least one BSS that is a member of the same SRG of the transmitting STA if the corresponding bit of the bitmap is set to 1. If a bit in the bitmap is set to 0, then no BSS in the same SRG of the transmitting STA uses the corresponding Partial BSSID value.

9.4.2.244 NDP Feedback Report Parameter Set element

The format of the NDP feedback report Parameter Set element is defined in Figure 9-589de (NDP Feedback Report Parameter Set element).

	Element ID	Length	Element ID Extension	Resource Request Buffer Threshold Exponent
Octets:	1	1	1	1

Figure 9-589de—NDP Feedback Report Parameter Set element

The Element ID, Length, and Element ID Extension fields are defined in 9.4.2.1 (General).

The Resource Request Buffer Threshold Exponent is used to calculate the buffer threshold between two different resource requests, as defined in 27.5.2.7.3.1. The Resource request buffer threshold value is equal to $2^{(\text{Ressource Request Buffer Threshold Exponent})}$ octets.

9.4.2.245 ESS Report element

The format of the ESS Report element is shown in Figure 9-589df (ESS Report element).

	Element ID	Length	Element ID Extension	ESS Information
Octets:	1	1	1	1

Figure 9-589df—ESS Report element

The Element ID, Length and Element ID Extension fields are defined in 9.4.2.1 (General).

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The format of the ESS Information field is defined in Figure 9-589dg (ESS Information field).

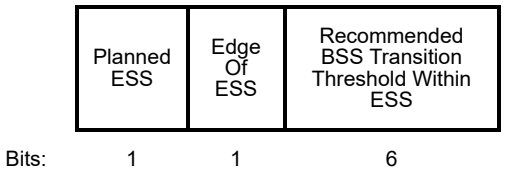


Figure 9-589dg—ESS Information field

The Planned ESS subfield indicates whether the BSS is part of an ESS which is planned with several BSSs in overlapping configuration. This subfield is set to 1 to indicate that the ESS is deployed to ensure blanket coverage over the Extended Service Area (ESA). Otherwise this subfield is set to 0 and the Edge Of ESS and Recommended BSS Transition Threshold Within The ESS subfields are reserved.

The Edge Of ESS subfield indicates whether the BSS is at the edge of the ESS. This subfield is set to 1 to indicate the BSS is at the edge of the ESS. Otherwise this subfield is set to 0.

The Recommended BSS Transition Threshold Within ESS subfield indicates the RSSI below which an associated STA is recommended to initiate BSS transition to a neighbor BSS belonging to the ESS.

The resolution for the Recommended BSS Transition Threshold Within The ESS subfield is 1 dB. The encoding is defined in Table 9-262ag (Recommended BSS Transition Threshold Within ESS subfield encoding).

Table 9-262ag—Recommended BSS Transition Threshold Within ESS subfield encoding

Value	Description
0–62	–100 dBm to –37 dBm
63	No recommendation

The use of the ESS Report element is described in 11.24.7.5 (Planned ESS).

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9.6 Action frame format details

9.6.4 DLS Action frame details

9.6.4.2 DLS Request frame format

Insert the following new rows (header row shown for convenience) into Table 9-299 (DLS Request frame Action field format) after the row for Order 11:

Table 9-299—DLS Request frame Action field format

Order	Information	Notes
12	HE Capabilities	The HE Capabilities element is present when dot11HEOption-Implemented is true; otherwise it is not present.
13	HE Operation	The HE Operation element is present when dot11HEOptionImplemented is true; otherwise it is not present.

9.6.4.3 DLS Response frame format

Insert the following new row (header row shown for convenience) into Table 9-300 (DLS Response frame Action field format) after the row for Order 11:

Table 9-300—DLS Response frame Action field format

Order	Information	Notes
12	HE Capabilities	The HE Capabilities element is present when dot11HEOption-Implemented is true; otherwise it is not present.

9.6.8 Public Action details

9.6.8.16 TDLS Discovery Response frame format

Insert the following new row into Table 9-317 (TDLS Discovery Response Action field format) after the row for Order 18:

Table 9-317—TDLS Discovery Response Action field format

Order	Information	Notes
19	HE Capabilities	The HE Capabilities element is present when dot11HEOption-Implemented is true; otherwise it is not present, The HE Capabilities element is defined in 9.4.2.237 (HE Capabilities element)

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9.6.8.36 FILS Discovery frame format

Change Table 9-325a (FILS Discovery frame format) as follows (only modified rows are shown):

Table 9-325a—FILS Discovery frame format

Order	Information	Notes
~~6~~	~~Vendor Specific element~~	~~One or more Vendor Specific elements are optionally present.~~
7	TIM element	The TIM element is optionally present when dot11HEOption-Implemented is true, otherwise it is not present.
8	Broadcast TWT element	The broadcast TWT element is optionally present when dot11HEOptionImplemented is true, otherwise it is not present.

Change Table 9-325b (BSS Operating Channel Width) as follows:

Table 9-325b—BSS Operating Channel Width

BSS Operating Channel Width field	HR/DSSS, OFDM, ERP, HT, ~~or~~ VHT or HE BSS operating channel width	TVHT BSS operating channel width
0	20 MHz or 22 MHz	TVHT_W
1	40 MHz	TVHT_W+W
2	80 MHz	TVHT_2W
3	160 MHz or 80+80 MHz	TVHT_4W or TVHT_2W+2W
4-7	Reserved	Reserved

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Change Table 9-325d (PHY Index subfield) as follows:

Table 9-325d—PHY Index subfield

PHY Index subfield	PHY
0	HR/DSSS (see Clause 17)
1	ERP-OFDM (see Clause 18 and Clause 19)
2	HT (see Clause 20)
3	VHT (see Clause 22) or TVHT (see Clause 23)
4	HE (see Clause 28)
45-7	Reserved

Change Table 9-325d (PHY Index subfield) as follows:

Table 9-325e—FILS Minimum Rate

FILS Minimum Rate subfield	PHY Index subfield is 0 (HR/ DSSS)	PHY Index subfield is 1 (ERP-OFDM)	PHY Index subfield is 2 (HT)	PHY Index subfield is 3 (VHT or TVHT)	PHY Index subfield is 4 (HE)
0	1 Mbps	6 Mbps	MCS 0	MCS 0	MCS 0
1	2 Mbps	9 Mbps	MCS 1	MCS 1	MCS 1
2	5.5 Mbps	12 Mbps	MCS 2	MCS 2	MCS 2
3	11 Mbps	18 Mbps	MCS 3	MCS 3	MCS 3
4	Reserved	24 Mbps	MCS 4	MCS 4	MCS 4
5-7	Reserved	Reserved	Reserved	Reserved	Reserved

Change the following paragraph:

Channel Center Frequency Segment 1 subfield is set to the index of the channel center frequency of the frequency segment 1 for an 80+80 MHz VHT or HE BSS, if the FILS Discovery frame is transmitted as a non-HT duplicate PPDUs at an 80+80 MHz channel bandwidth; otherwise, the subfield is not present.

Insert the following at the end of the subclause:

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The FILS Discovery frame may include a TIM element, which is defined in 9.4.2.6 (TIM element), for operation as defined in 27.14.3 (Opportunistic power save).

The FILS Discovery frame may include a broadcast TWT element, which is defined in 9.4.2.200 (TWT element), to aid unassociated STAs make decisions related to power save (as described in 27.14.2 (Power save with UORA)) and transmissions to the AP via random access as described in 27.5.5 (UL OFDMA-based random access (UORA)).

9.6.13 TDLS Action field formats

9.6.13.2 TDLS Setup Request Action field format

Insert the following new row into Table 9-343 (Information for TDLS Setup Request Action field) after the row for Order 23:

Table 9-343—Information for TDLS Setup Request Action field

Order	Information	Notes
24	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented is true; otherwise it is not present. The HE Capabilities element is defined in 9.4.2.237 (HE Capabilities element)

9.6.13.3 TDLS Setup Response Action field format

Insert the following new row into Table 9-344 (Information for TDLS Setup Response Action field) after the row for Order 25:

Table 9-344—Information for TDLS Setup Response Action field

Order	Information	Notes
26	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented is true and the Status Code is SUCCESS; otherwise it is not present. The HE Capabilities element is defined in 9.4.2.237 (HE Capabilities element)

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9.6.13.4 TDLS Setup Confirm Action field format

Insert the following new row (header row shown for convenience) into Table 9-345 (Information for TDLS Setup Confirm Action field) after the row for Order 12:

Table 9-345—Information for TDLS Setup Confirm Action field

Order	Information	Notes
13	HE Operation	The HE Operation element is present when dot11HEOptionImplemented is true, the TDLS Setup Response frame contained an HE Capabilities element and the Status Code is SUCCESS; otherwise it is not present. The HE Operation element is defined in 9.4.2.238 (HE Operation element).

9.6.16 Self-protected Action frame details

9.6.16.2 Mesh Peering Open frame format

9.6.16.2.2 Mesh Peering Open frame details

Insert the following new row into Table 9-365 (Mesh Peering Open frame Action field format) after the row for Order 22:

Table 9-365—Mesh Peering Open frame Action field format

Order	Information	Notes
23	HE Capabilities	The HE Capabilities element is present when dot11HEOptionImplemented is true; otherwise it is not present.
24	HE Operation	The HE Operation element is present when dot11HEOptionImplemented is true; otherwise it is not present.

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9.6.16.3 Mesh Peering Confirm frame format

9.6.16.3.2 Mesh Peering Confirm frame details

Insert the following new row into Table 9-366 (Mesh Peering Open frame Action field format) after the row for Order 18:

Table 9-366—Mesh Peering Open frame Action field format

Order	Information	Notes
19	HE Capabilities	The HE Capabilities element is present when dot11HEOption-Implemented is true; otherwise it is not present.
20	HE Operation	The HE Operation element is present when dot11HEOptionImplemented is true; otherwise it is not present.

9.6.28 HE Action frame details

9.6.28.1 HE Action field

An HE Action field, in the octet immediately after the Category field, differentiates the HE Action frame formats. The HE Action field values associated with each frame format within the HE category are defined in Table 9-421z (HE Action field values).

Table 9-421z—HE Action field values

Value	Meaning
0	HE Compressed Beamforming And CQI
1	Quiet Time Period
2-255	Reserved

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9.6.28.2 HE Compressed Beamforming And CQI frame format

The HE Compressed Beamforming And CQI frame is an Action No Ack frame of category HE. The Action field of an HE Compressed Beamforming And CQI frame contains the information shown in Table 9-421aa (HE Compressed Beamforming And CQI frame Action field format).

Table 9-421aa—HE Compressed Beamforming And CQI frame Action field format

Order	Information
1	Category
2	HE Action
3	HE MIMO Control
4	HE Compressed Beamforming Report (see 9.4.1.63 (HE Compressed Beamforming Report field))
5	HE MU Exclusive Beamforming Report (see 9.4.1.64 (HE MU Exclusive Beamforming Report field))
6	HE CQI-only Report (see 9.4.1.65 (HE CQI-only Report field))

The Category field is defined in Table 9-47 (Category values).

The HE Action field is defined in Table 9-421z (HE Action field values).

The HE MIMO Control field is always present in the frame. The presence and contents of the HE Compressed Beamforming Report field, HE MU Exclusive Beamforming Report field and HE CQI-only Report field are dependent on the values of the Feedback Type subfield of the HE MIMO Control field.

No vendor-specific elements are present in the HE Compressed Beamforming and CQI frame.

9.6.29 Protected HE Action frame details

9.6.29.1 Protected HE Action field

A Protected HE Action field, in the octet immediately after the Category field, differentiates the Protected HE Action frame formats. The Protected HE Action field values associated with each frame format within the HE category are defined in Table 9-421z (HE Action field values).

Table 9-421z—Protected HE Action field values

Value	Meaning
0	HE BSS Color Change Announcement
1-255	Reserved

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9.6.29.2 HE BSS Color Change Announcement frame format

The HE BSS Color Change Announcement frame is an Action or Action No ACK frame of category Protected HE. The Action field of an HE BSS Color Change Announcement frame contains the information shown in Table 9-421aa (HE BSS Color Change Announcement frame Action field format).

Table 9-421aa—HE BSS Color Change Announcement frame Action field format

Order	Information
1	Category
2	Protected HE Action
3	BSS Color Change Announcement element (see 9.4.2.241 (BSS Color Change Announcement element))

The Category field is defined in Table 9-47 (Category values).

The Protected HE Action field is defined in Table 9-421z (Protected HE Action field values).

The BSS Color Change Announcement element as defined in 9.4.2.241 (BSS Color Change Announcement element) is always present in the frame.

No Vendor-Specific elements are present in the HE BSS Color Change Announcement frame.

9.6.30 Quiet Time Period Action frame details

The Quiet Time Period action frame is an Action No Ack frame of category HE. The Action field of a Quiet Time Period contains the information shown in Table 9-421ab (Quiet Time Period Frame Body).

Table 9-421ab—Quiet Time Period Frame Body

Order	Information
1	Category
2	HE Action
3	Quiet Time Period

The Category field is defined in Table 9-47 (Category values).

The HE Action field is defined in Table 9-421z (HE Action field values).

The Quiet Time Period is always present in the frame. The presence and contents of the Quiet Time Setup field, Quiet Time Request field, and Quiet Time Response field are dependent on the values of the Control field of Quiet Time Period element.

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9.7 Aggregate MPDU (A-MPDU)

9.7.1 A-MPDU format

Change the 4th paragraph as follows:

The EOF Padding field is shown in Figure 9-739 (EOF Padding field format). This is present only in a VHT or HE PPDU.

Change the 6th and subsequent paragraphs as follows:

In a VHT or HE PPDU, the following padding is present, as determined by the rules in 10.13.6 (A-MPDU padding for VHT PPDU):

— 0–3 octets in the Padding subfield of the final A-MPDU subframe (see Figure 9-740 (A-MPDU subframe format)) before any EOF padding subframes. The content of these octets is unspecified.

— Zero or more EOF padding subframes in the EOF Padding Subframes subfield.

— 0–3 octets in the EOF Padding Octets subfield. The content of these octets is unspecified.

An A-MPDU pre-EOF padding refers to the contents of the A-MPDU up to, but not including, the EOF Padding field.

NOTE—A-MPDU pre-EOF padding includes any A-MPDU subframes with 0 in the MPDU Length field and 0 in the EOF field inserted in order to meet the minimum MPDU start spacing requirement.

The maximum length of an A-MPDU in an HT PPDU is 65 535 octets. The maximum length of an A-MPDU in a DMG PPDU is 262 143 octets. The maximum length of an A-MPDU pre-EOF padding in a VHT PPDU is 1 048 575 octets. The maximum length of an A-MPDU pre-EOF padding in an HE PPDU is 4 194 303 octets. The length of an A-MPDU addressed to a particular STA can be further constrained as described in 10.13.2 (A-MPDU length limit rules).

Change Table 9-422 as follows:

Table 9-422— MPDU delimiter fields (non-DMG)

Field	Size (bits)	Description
EOF	1	End of frame indication. Set to 1 in an A-MPDU subframe that has 0 in the MPDU Length field and that is used to pad the A-MPDU in a VHT or HE PPDU as described in 10.13.6 (A-MPDU padding for VHT PPDU). Set to 1 in the MPDU delimiter of an S-MPDU as described in 10.13.7 (Setting the EOF field of the MPDU delimiter)) and set to 1 in a MPDU delimiter preceding a QoS Data frame or Action frame soliciting an Ack frame in response that are contained in an ack-enabled multi-TID A-MPDU as described in 10.13.7 (Setting the EOF field of the MPDU delimiter) and 27.10.4.3 (Ack-enabled multi-TID A-MPDU operation). Set to 0 otherwise.
Reserved	1	
MPDU Length	14	Length of the MPDU in octets. Set to 0 if no MPDU is present. An A-MPDU subframe with 0 in the MPDU Length field is used as defined in 10.13.3 (Minimum MPDU Start Spacing field) to meet the minimum MPDU start spacing requirement and also to pad the A-MPDU to fill the available octets in a VHT or HE PPDU as defined in 10.13.6 (A-MPDU padding for VHT PPDU).
CRC	8	8-bit CRC of the preceding 16 bits

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Table 9-422— MPDU delimiter fields (non-DMG)

Delimiter Signature	8	Pattern that may be used to detect an MPDU delimiter when scanning for an MPDU delimiter. The unique pattern is 0x4E (see NOTE below).
NOTE—The ASCII value of the character 'N' was chosen as the unique pattern for the value in the Delimiter Signature field.		

Change the 12th paragraph as follows:

The format of the MPDU Length field when transmitted by a non-DMG STA is shown in Figure 9-743. The MPDU Length Low subfield contains the 12 low order bits of the MPDU length. In a VHT or HE PPDU, the MPDU Length High subfield contains the two high order bits of the MPDU length. In an HT PPDU, the MPDU Length High subfield is reserved.

Replace Equation (9-5) with the equation below (introductory sentence and variable list unchanged):

The MPDU length value is derived from the MPDU Length field subfields as follows:

$$L_{MPDU} = \begin{cases} L_{low} + L_{high} \times 4096, \text{ for a VHT and HE PPDU} \\ L_{low}, \text{ for an HT PPDU} \\ L, \text{ for a DMG PPDU} \end{cases} \quad (9\text{-}5)$$

where

L_{low} is the value of the MPDU Length Low subfield

L_{high} is the value of the MPDU Length High subfield

L is the value of the MPDU Length field

Change the NOTE as follows:

NOTE—The format of the MPDU Length field maintains a common encoding structure for ~~both~~ HE, VHT and HT PPDUs. For HT PPDUs, only the MPDU Length Low subfield is used, while for VHT and HE PPDUs, both subfields are used.

9.7.3 A-MPDU contents

Change the 1st paragraph of this subclause as follows:

In a non-DMG PPDU, an A-MPDU is a sequence of A-MPDU subframes carried in a single PPDU with one of the following combinations of RXVECTOR or TXVECTOR parameter values:

- The FORMAT parameter set to VHT
- The FORMAT parameter set to HT_MF or HT_GF and the AGGREGATION parameter set to 1
- The FORMAT parameter set to S1G, S1G_DUP_1M, or S1G_DUP_2M and the AGGREGATION parameter set to 1
- The FORMAT parameter set to HE_SU, HE_MU, HE_TRIG or HE_EXT_SU

Insert the following paragraph:

An A-MPDU carried in an HE SU PPDU, HE ER SU PPDU, HE TB PPDU or HE MU PPDU can include MPDUs with different values of the TID field as described in 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU).

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Change the 3rd paragraph as follows:

All of the MPDUs within an A-MPDU are addressed to the same RA. All of the MPDUs within an A-MPDU have the same TA. All QoS Data frames within an A-MPDU that have a TID for which an HT-immediate block ack agreement exists have the same value for the Ack Policy subfield of the QoS Control field.

Change the 5th paragraph as follows:

The Duration/ID fields in the MAC headers of all MPDUs in an A-MPDU carry the same value. The Duration/ID fields in the MAC headers of the MPDUs in the A-MPDUs carried in ~~the same~~ a VHT MU PPDU and an HE MU PPDU ~~all~~ carry the same value.

NOTE 1—The reference point for the Duration/ID field is the end of the PPDU carrying the MPDU. Setting the Duration/ID field to the same value in the case of A-MPDU aggregation means that each MPDU consistently specifies the same NAV setting.

Change the 7th and 8th paragraph as follows:

An A-MPDU is transmitted in one of the contexts specified in Table 9-424 (A-MPDU contexts) as defined by the description in the "Definition of context" column~~, independently of whether the A-MPDU is contained in a VHT MU PPDU or an SU PPDU~~. The content of an A-MPDU depends on the context at which it is transmitted as defined in the tables below. Ordering of MPDUs within an A-MPDU is not constrained, except where noted in these tables. See 10.13.1 (A-MPDU contents).

A VHT MU PPDU does not carry more than one A-MPDU that contains one or more MPDUs soliciting an immediate response if the immediate response is carried in a PPDU that is not an HE TB PPDU. An HE MU PPDU can carry more than one A-MPDU each of which contains one or more MPDUs soliciting an immediate response if it is carried in an HE TB PPDU.

NOTE 2—The TIDs present in a data enabled A-MPDU context are also constrained by the channel access rules (for a TXOP holder; see 10.22.2 (HCF contention based channel access (EDCA)) and 10.22.3 (HCF controlled channel access (HCCA))) the TXOP responder rules (see 27.10 (A-MPDU operation), and 27.5.3 (UL MU operation)) and the RD response rules (for an RD responder, see 10.28.4 (Rules for RD responder)). This is not shown in these tables.

NOTE 3—If a STA supports A-MSDUs of 7935 octets (indicated by the Maximum A-MSDU Length field in the HT Capabilities element), A-MSDUs transmitted by that STA within an A-MPDU carried in a PPDU with FORMAT HT_MF or HT_GF are constrained so that the length of the QoS Data frame carrying the A-MSDU is no more than 4095 octets. The 4095-octet MPDU length limit does not apply to A-MPDUs carried in VHT, HE or DMG PPDUs. The use of A-MSDU within A-MPDU might be further constrained as described in 9.4.1.14 (Block Ack Parameter Set field) through the operation of the A-MSDU Supported field.

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Change Table 9-424 (A-MPDU Contexts) as follows:

Table 9-424—A-MPDU Contexts

Name of Context	Definition of Context	Table defining permitted contents
Data Enabled Immediate Response	The A-MPDU is transmitted outside a PSMP sequence by a TXOP holder, TXOP responder or an RD responder including potential immediate responses.	Table 9-425 (A-MPDU contents in the data enabled immediate response context)
Data Enabled No Immediate Response	The A-MPDU is transmitted outside a PSMP sequence by a TXOP holder, TXOP responder that does not include or solicit an immediate response. See NOTE.	Table 9-426 (A-MPDU contents in the data enabled no immediate response context)
PSMP	The A-MPDU is transmitted within a PSMP sequence.	Table 9-427 (A-MPDU contents in the PSMP context)
Control Response	The A-MPDU is transmitted by a STA that is neither a TXOP holder nor an RD responder or the A-MPDU is transmitted by AP in an HE BSS that also needs to transmit one of the following immediate response frames: Ack BlockAck frame with a TID for which an HT-immediate block ack agreement exists Multi-STA BA for acknowledging multi-TID A-MPDU	Table 9-428 (A-MPDU contents MPDUs in the control response context)
S-MPDU context	The A-MPDU is transmitted within a VHT PPDU or an HE PPDU and contains an S-MPDU.	Table 9-429 (A-MPDU contents in the S-MPDU context)

NOTE—This context includes cases when no response is generated or when a response is generated later by the operation of the delayed block ack rules.

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Change Table 9-425 (A-MPDU contents in the data enabled immediate response context) as follows:

Table 9-425—A-MPDU contents in the data enabled immediate response context

MPDU Description	Conditions	
Ack	If the preceding PPDU contains an MPDU that requires an Ack frame response, a single Ack frame at the start of the A-MPDU.	In a non-DMG STA <u>other than an HE STA</u>: at most one of ~~these~~ <u>Ack and HT-immediate BlockAck</u> MPDUs is present. <u>In an HE STA: at most one of these MPDUs is present.</u> In a DMG STA: at most one Ack frame is present, and zero or more HT-immediate BlockAck frames are present.
HT-immediate BlockAck	In a non-DMG STA: if the preceding PPDU contains an implicit or explicit block ack request for a TID for which an HT-immediate block ack agreement exists, at most one BlockAck frame for this TID, in which case it occurs at the start of the A-MPDU. In a DMG STA: if the preceding PPDU contains an implicit or explicit block ack request for a TID for which an HT-immediate block ack agreement exists, one or more copies of the same BlockAck for this TID.	
<u>Multi-STA BlockAck</u>	<u>In an HE STA: If the preceding PPDU that carried a multiple-TID A-MPDU contains implicit or explicit block ack requests for multiple TIDs for which HT-immediate block ack agreement exist, at most one Multi-STA BA frame, in which case it occurs at the start of the A-MPDU.</u>	
Delayed BlockAcks	BlockAck frames with the BA Ack Policy subfield equal to No Acknowledgment with a TID for which an HT-delayed block ack agreement exists.	
Delayed block ack data	QoS Data frames with a TID that corresponds to a Delayed or HT-delayed block ack agreement. These have the Ack Policy field equal to Block Ack.	
Action No Ack	Action No Ack frames.	
Delayed BlockAckReqs	BlockAckReq frames with a TID that corresponds to an HT-delayed block ack agreement in which the BA Ack Policy subfield is equal to No Acknowledgment.	

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Table 9-425—A-MPDU contents in the data enabled immediate response context *(continued)*

MPDU Description	Conditions	
Data frames without HT-immediate block ack agreement	QoS Data frames with multiple TIDs which have no HT-immediate block ack agreement See NOTE 1.	Of these, at most one of the following is present in a non-DMG BSS except HE BSS: — One or more QoS Data frames with the Ack Policy field equal to Implicit Block Ack Request — A BlockAckReq frame Of these, at most one of the following is present in a DMG BSS: — One or more QoS Data frames with the Ack Policy field equal to Implicit Block Ack Request — QoS Null MPDU with Ack Policy set to No Ack — A BlockAckReq frame with an optional QoS Null MPDU with Ack Policy set to No Ack In a single TID A-MPDU context between two HE STAs at most one of the following is present: — One or more QoS Data frames with a single TID value with the Ack Policy field equal to Implicit Block Ack Request or HTP Ack or Block Ack, zero or more QoS Null frames with Ack Policy set to No Ack, and zero or more Basic Trigger frames — One frame with a single TID value with the Ack Policy field equal to Normal Ack or one Action frame, at least one of QoS Null frame with Ack Policy set to No Ack and Trigger frame — QoS Null MPDU with Ack Policy set to No Ack — One BlockAckReq — Basic, MU-BAR, GCR MU-BAR, BQRP, or BSRP Trigger frame only when AP transmits the A-MPDU. In a non-ack-enabled multi-TID A-MPDU context between two HE STAs, at most one of the following is present: — Two or more QoS Data frames from two or more TIDs with the Ack Policy field equal to Implicit Block Ack Request, HTP Ack, or BlockAck, zero or more QoS Null frames with Ack Policy set to No Ack, and zero or more Basic Trigger frames. There are at least two different values or TID subfield in this context. — One Multi-TID BlockAckReq frame — Basic Trigger frame, MU-BAR Trigger frame, GCR MU-BAR Trigger frame, BQRP Trigger frame or BSRP Trigger frame only when AP transmits the A-MPDU In an ack-enabled multi-TID A-MPDU context between two HE STAs at most one of the following is present: — Zero or more QoS Data frames from one or more TIDs with the Ack Policy field equal to Implicit BAR, HTP Ack, Normal Ack or BlockAck, zero or more QoS Null frames with Ack Policy set to No Ack, up to one Action frame, and zero or more Basic Trigger frames. There are at least two nonzero length MPDU delimiters in the A-MPDU of which at least one has the EOF field equal to 1. — Basic, MU-BAR, GCR MU-BAR, BQRP, or BSRP Trigger frame only when AP transmits the A-MPDU
Data frames sent under an HT-immediate block ack agreement	QoS Data frames with the same TID, which corresponds to an HT-immediate block ack agreement. QoS Data frames with multiple TIDs, which correspond to multiple HT-immediate block ack agreements. See NOTE 1.	
QoS Null MPDUs with Ack Policy set to No Ack	In a DMG BSS, QoS Null MPDUs with Ack Policy set to No Ack. In an HE BSS, QoS Null MPDUs with Ack Policy set to No Ack.	
Immediate BlockAckReq	~~At~~ In a single TID A-MPDU context, at most one BlockAckReq frame with a TID that corresponds to an HT-immediate block ack agreement. In multi-TID A-MPDU context, at most one multi-TID BlockAckReq frame with TIDs that correspond to HT-immediate block Ack agreements. This frame (if present) is the last MPDU in the A-MPDU. ~~It is not~~ Neither a BlockAckReq nor a Multi-TID BlockAckReq frame is present if any QoS Data frames ~~for that TID~~ are present.	
Action	At most one Action frame	
Trigger	One or more Trigger frames when the A-MPDU is sent by an HE AP where the Trigger Type field is Basic Trigger, MU-BAR, or BSRP. See NOTE 2 and NOTE 3.	

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Table 9-425—A-MPDU contents in the data enabled immediate response context *(continued)*

MPDU Description	Conditions
NOTE 1—~~These~~ The MPDUs from the same TID all have the Ack Policy field equal to the same value, which is either Implicit Block Ack Request, Normal Ack, HTP Ack or Block Ack. NOTE 2—An AP including a Trigger frame and BlockAck frame is not required to include QoS Data in that A-MPDU. NOTE 3—The BSRP and BQRP Trigger frames can be aggregated with other MPDUs in the A-MPDU if the receiver has indicated the support of receiving these trigger types in the BSRP BQRP A-MPDU Aggregation field of the HE Capabilities element.	

Change Table 9-426 (A-MPDU contents in the data enabled no immediate response context) as follows:

Table 9-426—A-MPDU contents in the data enabled no immediate response context

MPDU Description	Conditions
Delayed BlockAcks	BlockAck frames for a TID for which an HT-delayed block ack agreement exists with the BA Ack Policy subfield equal to No Acknowledgment.
Delayed Block Ack data	QoS Data frames with a TID that corresponds to a Delayed or HT-delayed block ack agreement. These have the Ack Policy field equal to Block Ack.
Data without a block ack agreement	QoS Data frames with a TID that does not correspond to a block ack agreement. These have the Ack Policy field equal to No Ack and the A-MSDU Present subfield equal to 0.
Action No Ack	Action No Ack frames.
Delayed BlockAckReqs	BlockAckReq frames with the BA Ack Policy subfield equal to No Acknowledgment and with a TID that corresponds to an HT-delayed block ack agreement.
Trigger	If the A-MPDU is transmitted by an AP, one or more Trigger frames where the Trigger Type field is Basic Trigger or BSRP. See NOTE 1.
QoS Null frame with Ack Policy field set to No Acknowledgment	Zero of more QoS Null MPDUs with Ack Policy field set to No Acknowledgment sent by an HE STA.
NOTE 1—An AP including Trigger frame and BlockAck is not required to include QoS Data in that A-MPDU.	

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Change Table 9-428 (A-MPDU contents MPDUs in the control response context) as follows:

Table 9-428—A-MPDU contents MPDUs in the control response context

MPDU	Conditions	
Ack	Ack frame transmitted in response to an MPDU that requires an Ack frame.	One Ack and BlockAck frame is present at the start of the A-MPDU between two STAs that are not both HE STAs. One of these is present at the start of the A-MPDU between two HE STAs.
BlockAck	BlockAck frame with a TID that corresponds to an HT-immediate block ack agreement.	
Multi-STA BlockAck	At most one Multi-STA BlockAck frame if: the preceding PPDU carries a multi-TID A-MPDU (see 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU)) that includes at least two frames soliciting an immediate response and contains: — Zero or more implicit or explicit block ack requests for multiple TIDs for which HT-immediate block ack agreement exists — Up to one Action frame — Zero or more MPDUs that solicit an immediate acknowledgement The preceding PPDU is an HE TB PPDU.	
Action No Ack	+HTC Action No Ack frames carrying a Management Action Body containing an explicit feedback response or BRP frame.	
QoS Null frame with Ack Policy field set to No Ack	Zero of more QoS Null MPDUs with Ack Policy field set to No Ack when the A-MPDU is sent by an HE STA.	

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10. MAC sublayer functional description

10.1 Introduction

Change as follows:

The MAC functional description is presented in this clause. The architecture of the MAC sublayer, including the distributed coordination function (DCF), the point coordination function (PCF), the hybrid coordination function (HCF), the mesh coordination function (MCF), the multi-user uplink access functions (UMTA and UORA), and their coexistence in an IEEE 802.11 LAN are introduced in 10.2 (MAC architecture). These functions are expanded on in 10.3 (DCF), 10.4 (PCF), 10.24 (HCF), ~~and~~ 10.25 (Mesh coordination function (MCF)), and 27.2 (HE channel access). Fragmentation and defragmentation are defined in 10.5 (MPDU fragmentation) and 10.6 (MPDU defragmentation). Multirate support is addressed in 10.7 (Multirate support). A number of additional restrictions to limit the cases in which MSDUs are reordered or discarded are described in 10.8 (MSDU transmission restrictions). Operation across regulatory domains is defined in 10.23 (Operation across regulatory domains). The block ack mechanism is described in 10.26 (Block acknowledgment (block ack)). The No Ack mechanism is described in 10.27 (No Acknowledgment (No Ack)). The protection mechanism is described in 10.28 (Protection mechanisms). Rules for processing MAC frames are described in 10.29 (MAC frame processing).

The PCF mechanism is obsolete. Consequently, the PCF mechanism might be removed in a later revision of the standard.

10.2 MAC architecture

10.2.1 General

Replace Figure 10-1 (Non-DMG non-S1G STA MAC architecture) with the following:

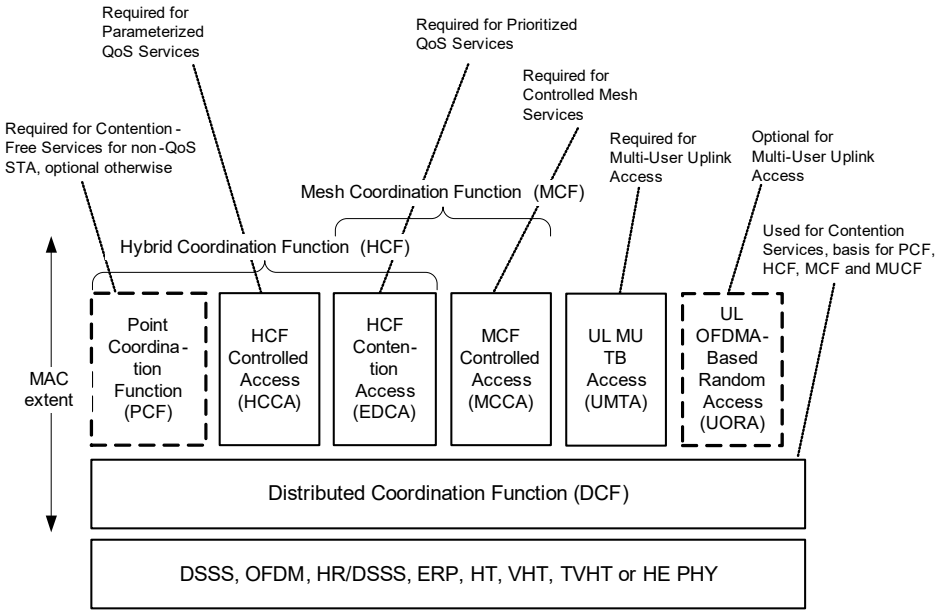


Figure 10-1—Non-DMG non-S1G STA MAC architecture

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Change the 2nd paragraph as follows:

In a non-DMG non-S1G STA:

- The MAC provides the PCF, HCF, ~~and~~ MCF, UMTA and UORA service~~s~~ using the services of the DCF.
- The PCF is optionally present in nonmesh STAs and absent otherwise.
- The HCF is present in QoS STAs and absent otherwise.
- The MCF is present in mesh STAs and absent otherwise.
- The UMTA is present in HE non-AP STAs and absent otherwise.
- The UORA is optionally present in HE non-AP STAs and absent otherwise.

10.2.4 Hybrid coordination function (HCF)

10.2.4.2 HCF contention based channel access (EDCA)

Insert the following after the 4th paragraph (the 4th paragraph begins "The QoS AP shall announce the EDCA parameters..."):

In addition, an HE AP may change the EDCA access parameters for non-AP HE STAs that are UL MU capable, by including an MU EDCA Parameter Set element in the Beacon frame, Probe Response frame, and (Re)Association Response frame. A non-AP HE STA that receives an MU EDCA Parameter Set element from its associated AP follows the rules defined in 27.2.6 (Obtaining an EDCA TXOP for HE non-AP STAs using MU EDCA parameters).

Change the 8th paragraph as follows:

BlockAckReq and BlockAck frames shall be sent using the same access category for medium access as the corresponding QoS Data frames. When an HE STA transmits a BlockAckReq, Multi-TID BlockAckReq or Multi-STA BlockAck frames, further constraints defined in 27.4 (HE block acknowledgement procedure) apply.

Insert a new subclause as follows after 10.2.5:

10.2.5a Multi-user uplink access (MUUA)

An HE non-AP STA also implements one or two UL multi-user access methods. The UL MU TB access (UMTA) is used when an HE AP triggers a group of HE non-AP STAs to transmit an HE TB PPDU. The optional UORA additionally allows an HE non-AP STA to access one of a number of resource units designated for random access by the HE AP.

The operation of UMTA is described in 27.5.3 (UL MU operation). The operation of UORA is described in 27.5.5 (UL OFDMA-based random access (UORA))).

Change the title and first paragraph of 10.2.6 as follows:

10.2.6 Combined use of DCF, PCF, ~~and~~ HCF, and MUUA

The DCF and a centralized coordination function (either PCF, ~~or~~ HCF, or MUUA) are defined so they may operate within the same BSS. When a PC is operating in a BSS, the PCF and DCF access methods alternate, with a CFP followed by a CP. This is described in greater detail in 10.4 (PCF). When an HC is operating in a BSS, it may generate an alternation of CFP and CP in the same way as a PC, using the DCF access method only during the CP. The HCF access methods (controlled and contention based) operate sequentially when

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the channel is in CP. Sequential operation allows the polled and contention based access methods to alternate, within intervals as short as the time to transmit a frame exchange sequence, under rules defined in 10.22 (HCF).

10.3 DCF

10.3.1 General

Change the 6th paragraph as follows:

The virtual CS mechanism is achieved by distributing reservation information announcing the impending use of the medium. The exchange of RTS and CTS frames prior to the actual Data frame is one means of distribution of this medium reservation information. The RTS and CTS frames contain a Duration field that defines the period of time that the medium is to be reserved to transmit the actual Data frame and the returning Ack frame. A STA receiving either the RTS frame (sent by the originating STA) or the CTS frame (sent by the destination STA) shall process the medium reservation. Thus, a STA might be unable to receive from the originating STA and yet still know about the impending use of the medium to transmit a Data frame. The exchange of MU-RTS and simultaneous CTS responses by HE STAs prior to the actual Data frames is another means of distribution of this medium reservation information.

Change the 12th paragraph as follows:

The use of the RTS/CTS mechanism is under control of dot11RTSThreshold if dot11TXOPDurationRTSThreshold is 1023 or it is not present. This attribute may be set on a per-STA basis. This mechanism allows STAs to be configured to initiate RTS/CTS either always, never, or only on frames longer than a specified length.

The use of the RTS/CTS mechanism is under control of dot11TXOPDurationRTSThreshold when dot11TXOPDurationRTSThreshold is not 1023. When this mechanism is enabled, a non-AP HE STA shall use an RTS/CTS exchange for individually addressed frames when the duration of the TXOP is greater than or equal to dot11TXOPDurationRTSThreshold as defined in 27.2.1 (TXOP duration-based RTS/CTS).

NOTE 1—A STA configured not to initiate the RTS/CTS mechanism updates its virtual CS mechanism with the duration information contained in a received RTS or CTS frame, and responds to an RTS frame addressed to it with a CTS frame if permitted by medium access rules.

10.3.2 Procedures common to the DCF and EDCAF

10.3.2.1 CS mechanism

Change the 3rd and 4th paragraph of the subclause as follows:

A first virtual CS mechanism shall be provided by all MAC entities, and an additional second virtual CS mechanism shall be provided by an S1G MAC entity. The first mechanism is referred to as the NAV. The NAV maintains a prediction of future traffic on the medium based on duration information that is announced in RTS/CTS frames by non-DMG STAs, MU-RTS/CTS by HE STAs as defined in 27.2.5 (MU-RTS/CTS procedure), and RTS/DMG CTS frames by DMG STAs prior to the actual exchange of data. The duration information is also available in the MAC headers of all frames sent during the CP other than PV1 MAC frames and PS-Poll frames and during the BTI, the A-BFT, the ATI, the CBAP, and the SP. The duration information might also be available in the RXVECTOR parameter TXOP_DURATION when an HE PPDU is received.

The CS mechanism combines the NAV state and the STA's transmitter status with physical CS to determine the busy/idle state of the medium. The NAV may be thought of as a counter, which counts down to 0 at a uni-

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form rate. When the counter is 0, the virtual CS indication is that the medium is idle; when the counter is nonzero, the indication is busy. The virtual CS indication of medium for HE STAs with two NAVs is described in 27.2.4 (Updating two NAVs). If a DMG STA supports multiple NAVs as defined in 10.36.10 (Updating multiple NAV) and all counters are 0, the virtual CS indication is that the medium is idle; when at least one of the counters is nonzero, the indication is busy. The medium shall be determined to be busy when the STA is transmitting.

10.3.2.3 IFS

10.3.2.3.3 SIFS

Insert as the new last paragraph:

An HE STA that transmits an HE TB PPDU a SIFS after the end of a received PPDU follows the procedure in 27.5.3.3 (STA behavior for UL MU operation).

10.3.2.3.7 EIFS

Change 10.3.2.3.7 as follows:

A DCF shall use EIFS before transmission, when it determines that the medium is idle following reception of a frame for which the PHY-RXEND.indication primitive contained an error or a frame for which the FCS value was not correct. Similarly, a STA's EDCA mechanism under HCF shall use the EIFS-DIFS+AIFS[AC] interval. The duration of an EIFS is defined in 10.3.7 (DCF timing relations). The EIFS or EIFS-DIFS+AIFS[AC] interval shall begin following indication by the PHY that the medium is idle after detection of the erroneous frame, without regard to the virtual CS mechanism. The STA shall not begin a transmission until the expiration of the later of the NAV and EIFS or EIFS-DIFS+AIFS[AC]. The EIFS and EIFS-DIFS+AIFS[AC] are defined to provide enough time for another STA to acknowledge what was, to this STA, an incorrectly received frame before this STA commences transmission. Reception of an error-free frame or an HE PPDU containing the RXVECTOR parameter TXOP_DURATION which is not set to UNSPECIFIED during the EIFS or EIFS-DIFS+AIFS[AC] resynchronizes the STA to the actual busy/idle state of the medium, so the EIFS or EIFS-DIFS+AIFS[AC] is terminated and medium access (using DIFS or AIFS as appropriate and, if necessary, backoff) continues following reception of ~~that~~ the error-free frame or following an expected end of the received HE PPDU. At the expiration or termination of the EIFS or EIFS-DIFS+AIFS[AC], the STA reverts to the NAV and physical CS to control access to the medium.

EIFS shall not be invoked if the NAV is updated by the frame that would have caused an EIFS. EIFS shall not be invoked for an A-MPDU if one or more of its frames are received correctly. EIFS shall not be invoked if the RXVECTOR parameter TXOP_DURATION of a received HE PPDU is not set to UNSPECIFIED.

10.3.2.4 Setting and resetting the NAV

Change the 1st four paragraph as follows (the 2nd paragraph is broken into three paragraphs):

This subclause describes the setting and resetting of the NAV for non-DMG STAs and DMG STAs that support a single NAV. DMG STAs that support multiple NAVs shall update their NAVs according to the procedures described in 10.36.10 (Updating multiple NAV). HE STAs with two NAV timers shall update their NAV timers according to the procedures described in 27.2.4 (Updating two NAVs).

A STA that receives at least one valid frame in a PSDU can update its NAV with the information from any valid Duration field in the PSDU. When the received frame's RA is equal to the STA's own MAC address, the STA shall not update its NAV. Further, when the received frame is a DMG CTS frame and its TA is equal to the STA's own MAC address, the STA shall not update its NAV. For all other received frames the

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STA shall update its NAV when the received Duration is greater than the STA's current NAV value. Upon receipt of a PS-Poll frame, a STA shall update its NAV settings as appropriate under the data rate selection rules using a duration value equal to the time, in microseconds, required to transmit one Ack frame plus one SIFS, but only when the new NAV value is greater than the current NAV value. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer.

An HE AP that is not a TXOP holder shall update the NAV with the duration indicated by the RXVECTOR parameter TXOP_DURATION if and only if all of the following conditions are met:

— The RXVECTOR parameter TXOP_DURATION is not UNSPECIFIED.

— The HE AP does not receive a frame with the duration information indicated by a Duration field in the PSDU of the PPDU with the RXVECTOR parameter TXOP_DURATION

— The duration indicated by the RXVECTOR parameter TXOP_DURATION is greater than the current NAV value of the HE AP

An HE AP, that is a TXOP holder, shall update the NAV with the duration indicated by the RXVECTOR parameter TXOP_DURATION if and only if all of the following conditions are met:

— The RXVECTOR parameter TXOP_DURATION is not UNSPECIFIED.

— The HE AP does not receive a frame with the duration information indicated by a Duration field in the PSDU of the PPDU with the RXVECTOR parameter TXOP_DURATION

— The duration indicated by the RXVECTOR parameter TXOP_DURATION is greater than the current NAV value of the HE AP

— The RXVECTOR parameter BSS_COLOR is not equal to the BSS Color of the HE AP

NOTE 1—For an HE STA, only HE AP STA can maintain one NAV (see 27.2.4 (Updating two NAVs)).

NOTE 2—Based on the setting rule, if a STA receives a frame with the duration information indicated by both a Duration field in the PSDU and the RXVECTOR parameter TXOP_DURATION, then the duration information indicated by the RXVECTOR parameter TXOP_DURATION is ignored.

Various additional conditions may set or reset the NAV for a STA that is not an HE STA, as described in 10.4.3.3 (NAV operation during the CFP). When the NAV is reset, a PHY-CCARESET.request primitive shall be issued. The exact time of updating the NAV is described as follows. This NAV update operation is performed when the PHY-RXEND.indication primitive is received, except when the PHYRXEND.indication primitive is received before the end of the PPDU, in which case the NAV update is performed at the expected end of the PPDU.

Figure 10-5 (RTS/CTS/data/Ack and NAV setting) indicates the NAV for STAs that might receive the RTS frame, while other STAs might receive only the CTS frame, resulting in the lower NAV bar as shown (with the exception of the STA to which the RTS frame was addressed).

A STA that used information from an RTS frame or MU-RTS Trigger frame as the most recent basis to update its NAV setting is permitted to reset its NAV if no PHY-RXSTART.indication primitive is received from the PHY during a NAVTimeout period starting when the MAC receives a PHY-RXEND.indication primitive corresponding to the detection of the RTS frame or MU-RTS Trigger frame.

In non-DMG BSS, NAVTimeout period is equal to (2 x aSIFSTime) + (CTS_Time) + aRxPHYStartDelay + (2 x aSlotTime). When an RTS frame is used for the most recent NAV update, t~~T~~he "CTS_Time" shall be calculated using the length of the CTS frame and the data rate at which the RTS frame ~~used for the most recent NAV update was received~~. When an MU-RTS Trigger frame was used for the most recent NAV update, the "CTS_Time" shall be calculated using the length of the CTS frame and the 6 Mb/s data rate (see 27.2.5 (MU-RTS/CTS procedure)).

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10.3.2.10 MU acknowledgement procedure

Insert a new subclause heading before the first paragraph as follows:

10.3.2.10.1 Acknowledgement procedure for DL MU PPDU in SU format

Change the subclause as follows:

The acknowledgment procedure performed by a STA that receives MPDUs that were transmitted within a VHT MU PPDU or an HE MU PPDU sent by an AP is the same as the acknowledgment procedure for MPDUs that were not transmitted within a VHT MU PPDU or an HE MU PPDU sent by an AP, except when the STA is an HE STA that follows the rules defined in 27.3 (Fragmentation and defragmentation) and in 27.4 (HE block acknowledgement procedure).

NOTE—All MPDUs transmitted within a VHT MU PPDU or an HE MU PPDU sent by an AP are contained within A-MPDUs, and the rules specified in 9.7.3 (A-MPDU contents) prevent an immediate response carried in SU format to more than one of the A-MPDUs.

Responses to A-MPDUs within a VHT MU PPDU or an HE MU PPDU for DL transmission that are not immediate responses to the VHT MU PPDU or the HE MU PPDU sent by an AP are transmitted in response to explicit BlockAckReq frames by the AP. Examples of VHT MU PPDU frame exchange sequences are shown in Figure 10-11 (An example of a TXOP containing a VHT MU PPDU transmission with an immediate acknowledgment to the VHT MU PPDU) and Figure 10-12 (An example of a TXOP containing a VHT MU PPDU transmission with no immediate acknowledgment to the VHT MU PPDU).

Recovery within the TXOP that contains a VHT MU PPDU or an HE MU PPDU sent by an AP can be performed according to the rules of 10.22.2.7 (Multiple frame transmission in an EDCA TXOP). BlockAckRequest frames related to A-MPDUs within a VHT MU PPDU or an HE MU PPDU sent by an AP can be transmitted in a TXOP separate from the one that contained the VHT MU PPDU or the HE MU PPDU sent by an AP.

NOTE 1—A BlockAck frame or an Ack frame is sent in immediate response to the BlockAckReq frame for HT-immediate or HT-delayed Block Ack, respectively. An Ack frame might be sent in immediate response carried in SU format to an S-MPDU in the VHT MU PPDU or the HE MU PPDU sent by an AP. Responses to S-MPDUs for more than one STA contained in an HE MU PPDU are transmitted as specified in 10.3.2.10.2 (Acknowledgement procedure for DL MU PPDU in MU format). A Multi-STA BlockAck frame is sent in immediate response to the BlockAckReq frame with multi-TID BAR variant.

NOTE 2—A BlockAckReq~~uest~~ frame would typically not be sent to a STA in the case where the A-MPDU to the STA contained no MPDUs requiring acknowledgment. It could be sent if MPDUs in a previous A-MPDU remain unacknowledged.

Insert a new subclauses 10.3.2.10.2 and 10.3.2.10.3 as follows:

10.3.2.10.2 Acknowledgement procedure for DL MU PPDU in MU format

A non-AP STA that is the recipient, within an HE MU PPDU, of a QoS Data frame or QoS Null frame with ack policy HTP Ack, of an MU-BAR Trigger frame or a GCR MU-BAR Trigger frame, or of an MMPDU that solicits an immediate response, shall send the immediate response according to the scheduling information that is carried either in the Trigger frame(s) or UMRS Control field. If no valid Trigger frame(s) (see 9.3.1.23 (Trigger frame format)) or UMRS Control field (see 9.2.4.6.4.2 (UMRS Control)) is received, then the STA shall not respond. An example of UL OFDMA acknowledgement to an HE MU PPDU is shown in

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Figure 10-12a (An example of an HE MU PPDU transmission with an immediate UL OFDMA acknowledgement).

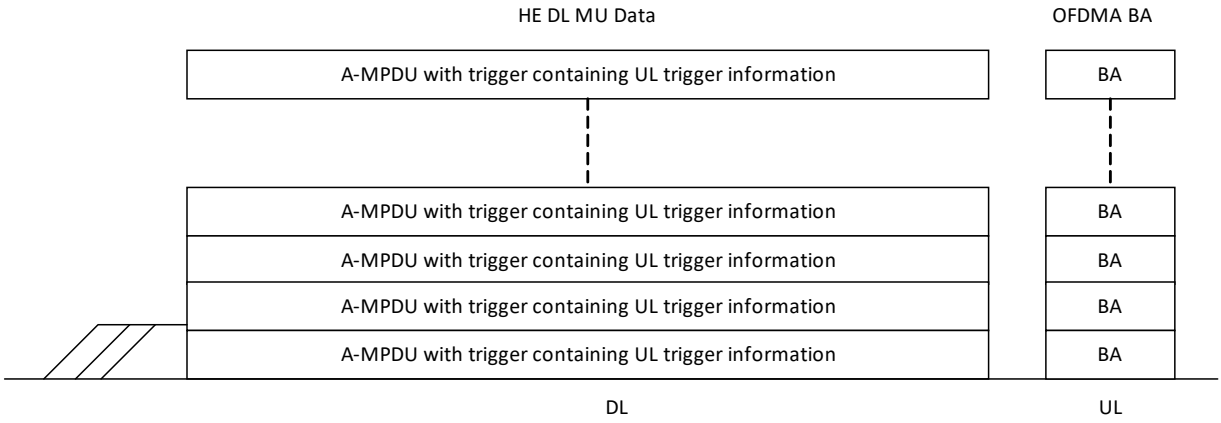


Figure 10-12a—An example of an HE MU PPDU transmission with an immediate UL OFDMA acknowledgement

An AP may use an MU-BAR Trigger frame or a GCR MU-BAR Trigger frame to solicit acknowledgment frames from multiple HE STAs to which the AP has sent QoS Data frame(s) with the Ack Policy subfield equal to Block Ack or from which the AP has not received immediate acknowledgement frames after sending QoS Data frame(s) with the Ack Policy subfield equal to HTP Ack in an HE MU PPDU.

10.3.2.10.3 Acknowledgement procedure for an UL MU transmission

When receiving frames from more than one STA that are part of an UL MU transmission (see 9.42.2) and that require an immediate acknowledgement (i.e., the Ack Policy subfield of the eliciting QoS Data frame is equal to Normal Ack or Implicit Block Ack Request), an AP may send either multiple BlockAck frames (or Ack frames) in an HE MU PPDU, or a Multi-STA BlockAck frame (see 27.4 (HE block acknowledgement procedure)). A Multi-STA BlockAck frame may be transmitted in a non-HT PPDU, non-HT duplicate PPDU, HT PPDU, VHT PPDU, HE SU PPDU, HE ER SU PPDU and OFDMA HE MU PPDU. After a successful reception of an UL frame requiring acknowledgment, transmission of the DL acknowledgement shall commence after a SIFS, without regard to the busy/idle state of the medium. Specifically, when an AP transmits an immediate acknowledgement in an HE MU PPDU in response to an A-MPDU sent in an HE TB PPDU, the AP should send it within the 20 MHz channel(s) where the pre-HE modulated fields of the HE TB PPDU sent by the STA are located. The immediate acknowledgement is an Ack frame, Compressed BlockAck frame or Multi-STA BlockAck frame.

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An example of a DL OFDMA BA is shown in Figure 10-12b (An example of an UL MU transmission with an immediate DL MU transmission containing individually addressed BlockAck frames acknowledging the frames received from the respective STAs).

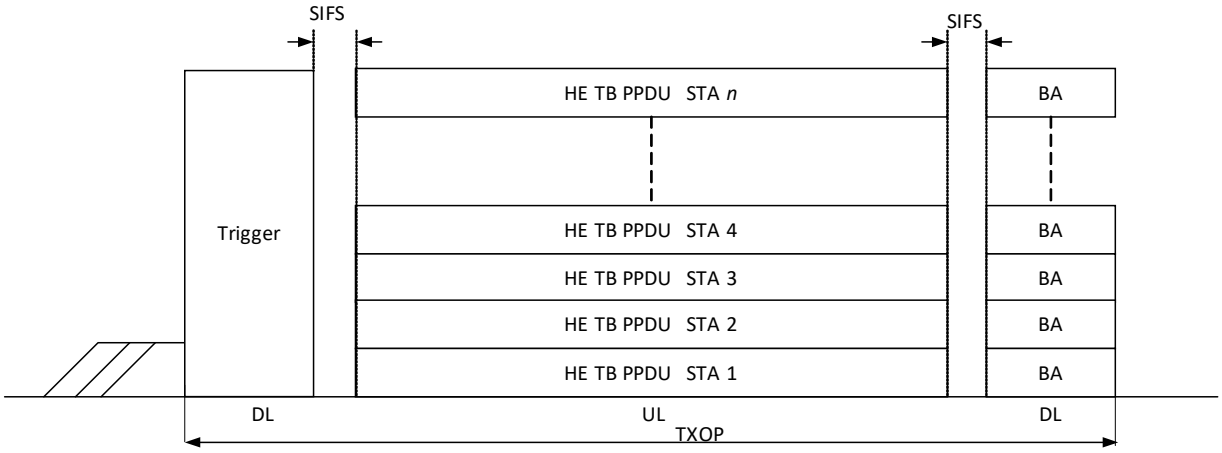


Figure 10-12b—An example of an UL MU transmission with an immediate DL MU transmission containing individually addressed BlockAck frames acknowledging the frames received from the respective STAs

An example of a Multi-STA BlockAck frame acknowledgement in a non-HT, HT, VHT or HE SU PPDU is given in Figure 10-12c (An example of UL MU transmissions with an immediate Multi-STA BlockAck frame acknowledging the MPDUs).

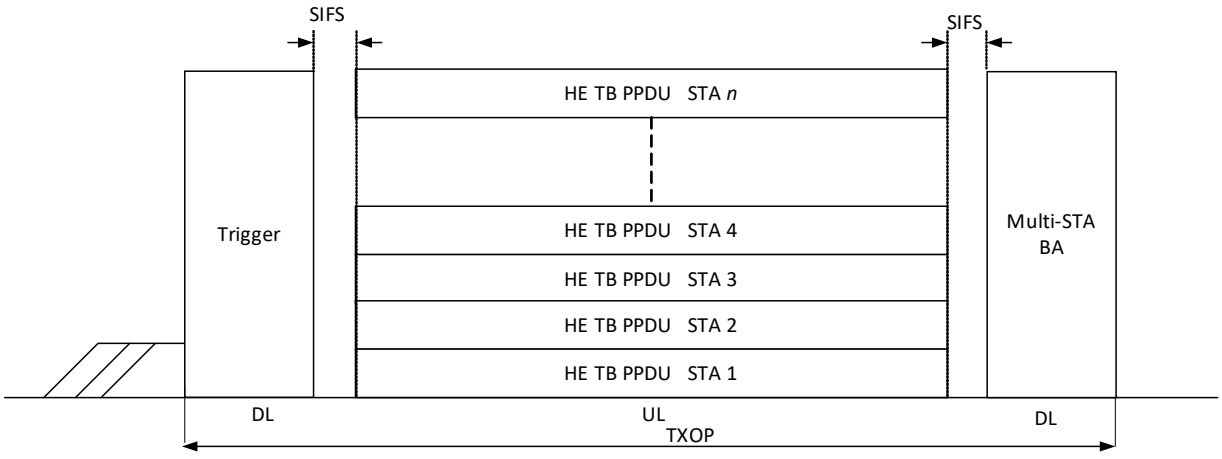


Figure 10-12c—An example of UL MU transmissions with an immediate Multi-STA BlockAck frame acknowledging the MPDUs

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An example of a Multi-STA BlockAck frame acknowledgement in a non-HT Duplicate PPDU is given in Figure 10-12d (An example of UL MU transmissions with an immediate DL non-HT duplicate PPDU containing the Multi-STA BlockAck frame).

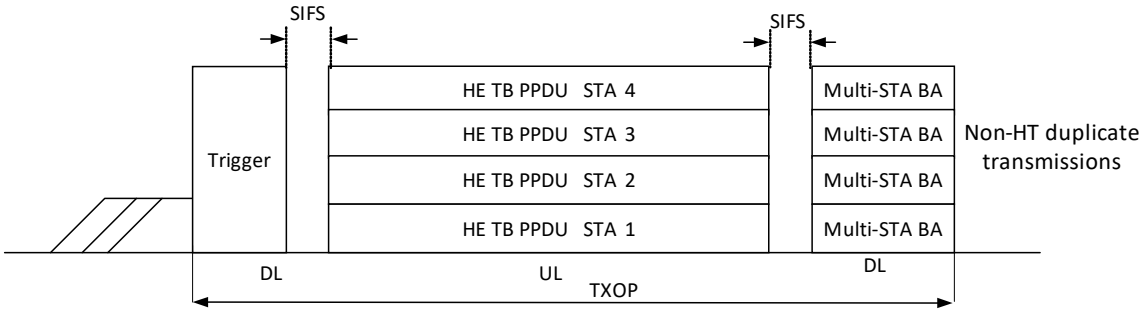


Figure 10-12d—An example of UL MU transmissions with an immediate DL non-HT duplicate PPDU containing the Multi-STA BlockAck frame

The Ack Policy subfield of a QoS data frame sent in an HE TB PPDU shall not be set to Block Ack.

A STA may send a BlockAckReq frame or Multi-TID BlockAckReq frame to solicit the acknowledgment frame(s) from an AP if it did not receive the immediate acknowledgement frames after sending QoS Data frame(s) in an HE TB PPDU with Ack Policy subfield equal to Normal Ack or Implicit Block Ack Request.

10.3.5 Individually addressed MPDU transfer procedure

Change 10.3.5 as follows:

~~A~~ When TXOP duration-based RTS is disabled, a STA using the DCF or EDCA shall use an RTS/CTS exchange for individually addressed frames when the length of the PSDU is greater than the length threshold indicated by dot11RTSThreshold. When TXOP duration-based RTS is enabled, a non-AP HE STA using EDCA shall use an RTS/CTS exchange as defined in 27.2.1 (TXOP duration-based RTS/CTS). A STA may also use an RTS/CTS exchange for individually addressed frames when it is necessary to distribute the NAV or when it is necessary to establish protection (see 10.26 (Protection mechanisms)). Otherwise a STA using the DCF shall not use the RTS/CTS exchange.

If dot11RTSThreshold is 0, all MPDUs shall be delivered with the use of RTS/CTS. ~~If dot11RTSThreshold is larger than the maximum PSDU length, all PSDUs shall be delivered without RTS/CTS exchanges.~~

NOTE—A non-AP STA that transmits the MPDUs in an HE TB PPDU is exempt from these requirements because the STA is not the TXOP holder.

When an RTS/CTS exchange is used, the PPDU containing the PSDU shall be transmitted starting one SIFS after the end of the CTS frame.

NOTE—No regard is given to the busy or idle status of the medium when transmitting this PSDU.

When an RTS/CTS exchange is not used, the PSDU shall be transmitted following the success of the basic access procedure. With or without the use of the RTS/CTS exchange procedure, the STA that is the destination of a Data frame shall follow the acknowledgment procedure.

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10.5 MPDU Fragmentation

Change the 4th paragraph as follows:

A STA shall be capable of receiving fragments, containing all or part of an MSDU, of arbitrary length that is less than or equal to the maximum MSDU size as specified in Table 9-19 (Maximum data unit sizes (in octets) and durations (in microseconds)) ~~defined in 9.2.3 (General frame format), plus any security encapsulation overhead, plus MAC header and FCS~~.

Insert the following at the end of the subclause:

An HE STA may also use the dynamic fragmentation as defined in 27.3 (Fragmentation and defragmentation) if the conditions described in 27.3.1 (General) are met.

10.7 Multirate support

10.7.1 Overview

Change the last two paragraphs as follows:

For specific PHYs, the value of the Duration/ID field is determined using the PLME-TXTIME.request primitive and the PLME-TXTIME.confirm primitive. These specific PHYs are defined in:

- Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification) for HR/DSSS
- Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) for OFDM
- Clause 18 (Extended Rate PHY (ERP) specification) for ERP
- Clause 19 (High Throughput (HT) PHY specification) for HT
- Clause 20 (Directional multi-gigabit (DMG) PHY specification) for DMG
- Clause 21 (Very High Throughput (VHT) PHY specification) for VHT
- Clause 22 (Television Very High Throughput (TVHT) PHY specification) for TVHT
- Clause 28 for HE

The two PLME-TXTIME primitives are defined in the respective PHY specifications:

- 16.3.4 (HR/DSSS TXTIME calculation) for HR TXTIME calculation
- 17.4.3 (OFDM TXTIME calculation) for OFDM TXTIME calculation
- 18.5.3.2 (ERP-OFDM TXTIME calculations)
- 19.4.3 (TXTIME calculation) for HT TXTIME calculation
- 20.12.3 (TXTIME calculation) for DMG PLME TXTIME calculation
- 21.4.3 (TXTIME and PSDU_LENGTH calculation) for VHT PLME TXTIME calculation
- 22.4.3 (TXTIME and PSDU_LENGTH calculation) for TVHT PLME TXTIME calculation
- 28.4.3 (TXTIME and PSDU_LENGTH calculation) for HE PLME TXTIME calculation

10.7.5 Rate selection for Data and Management frames

10.7.5.1 Rate selection for non-STBC Beacon and non-STBC PSMP frames

Change as follows:

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If the BSSBasicRateSet parameter is not empty, a non-STBC PSMP frame or a non-STBC Beacon frame shall be transmitted in a non-HT PPDU using one of the rates included in the BSSBasicRateSet parameter except for ER Beacon (see 10.7.5.8 (Rate selection for ER Beacon frames and group addressed frames)).

If the BSSBasicRateSet parameter is empty, the frame shall be transmitted in a non-HT PPDU using one of the mandatory PHY rates.

Insert a new subclause at the end of 10.7.5 as follows:

10.7.5.8 Rate selection for ER Beacon frames and group addressed frames

If the basic HE-MCS and NSS set of the AP that starts an ER BSS is not empty, the HE AP shall transmit ER Beacon frames and group-addressed frames in HE_ER_SU PPDUs using one of the <HE-MCS. NSS> tuples included in the basic HE-MCS and NSS set. If the basic HE-MCS and NSS set of the AP that starts an ER BSS is empty, the HE AP shall transmit the ER Beacon frame and group addressed frames in HE_ER_SU PPDUs using one of mandatory <HE-MCS, NSS> tuples.

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10.7.9 Modulation classes

Change Table as follows:

Table 10-6—Modulation classes

Description of modulation	Condition that selects this modulation class			
	Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) to Clause 18 (Extended Rate PHY (ERP) specification) PHYs or Clause 20 (Directional multi-gigabit (DMG) PHY specification) PHY	**Clause 19 (High Throughput (HT) PHY specification) PHY**	**Clause 21 (Very High Throughput (VHT) PHY specification) PHY**	**Clause 28**
DSSS and HR/ DSSS	Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) or Clause 16 transmission	FORMAT is NON_HT. NON_HT_MODULATION is ERP-DSSS or ERP-CCK.	N/A	FORMAT is NON_HT. NON_HT_MODULATION is ERP-DSSS or ERP-CCK.
ERP-OFDM	18.4 (ERP operating specifications (general)) transmission	FORMAT is NON_HT. NON_HT_MODULATION is ERP-OFDM.	N/A	FORMAT is NON_HT. NON_HT_MODULATION is ERP-OFDM.
OFDM	Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) transmission	FORMAT is NON_HT. NON_HT_MODULATION is OFDM or NON_HT_DUP_OFDM.	FORMAT is NON_HT. NON_HT_MODULATION is OFDM or NON_HT_DUP_OFDM.	FORMAT is NON_HT. NON_HT_MODULATION is OFDM or NON_HT_DUP_OFDM.
HT	N/A	FORMAT is HT_MF or HT_GF.	FORMAT is HT_MF or HT_GF.	FORMAT is HT_MF or HT_GF.
DMG Control	Clause 20 (Directional multi-gigabit (DMG) PHY specification) transmission and MCS is 0	NA	NA	N/A
DMG SC	Clause 20 (Directional multi-gigabit (DMG) PHY specification) transmission and $1 \leq MCS \leq 12$	NA	NA	N/A

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Table 10-6—Modulation classes *(continued)*

Description of modulation	Condition that selects this modulation class			
	Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) to Clause 18 (Extended Rate PHY (ERP) specification) PHYs or Clause 20 (Directional multi-gigabit (DMG) PHY specification) PHY	**Clause 19 (High Throughput (HT) PHY specification) PHY**	**Clause 21 (Very High Throughput (VHT) PHY specification) PHY**	**Clause 28**
DMG OFDM	Clause 20 (Directional multi-gigabit (DMG) PHY specification) transmission and $13 \leq MCS \leq 24$	NA	NA	N/A
DMG Low-power SC	Clause 20 (Directional multi-gigabit (DMG) PHY specification) transmission and $25 \leq MCS \leq 31$	NA	NA	N/A
VHT	N/A	N/A	FORMAT is VHT.	FORMAT is VHT
HE	N/A	N/A	N/A	FORMAT is HE_SU, HE_EXT_SU, HE_MU or HE_TRIG

10.7.10 Non-HT basic rate calculation

Change as follows:

This subclause defines how to convert an HT MCS ~~or,~~ a VHT-MCS or an HE-MCS to a non-HT basic rate for the purpose of determining the rate of the response frame. The value 1 of the DCM of an HE PPDU has no influence when deciding the non-HT basic rate for the purpose of determine the rate of the responding frame solicited by HE PPDU. It consists of two steps as follows:

a) Use the modulation and coding rate determined from the HT MCS (defined in 19.5 (Parameters for HT MCSs)) or VHT-MCS (defined in 21.5 (Parameters for VHT-MCSs)) or HE-MCS (defined in 28.5 (Parameters for HE-MCSs)) to locate a non-HT reference rate by lookup into Table 10-7.[1] In the case of an MCS with UEQM, the modulation of stream 1 is used.

b) The non-HT basic rate is the highest rate in the BSSBasicRateSet that is less than or equal to this non-HT reference rate.

[1] For example, if an HT PPDU transmission uses 64-QAM and coding rate of 3/4, the related non-HT reference rate is 54 Mb/s.

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Change Table 10-7 as follows:

Table 10-7—Non-HT reference rate

Modulation	Coding rate (R)	Non-HT reference rate (Mb/s)
BPSK	1/2	6
BPSK	3/4	9
QPSK	1/2	12
QPSK	3/4	18
16-QAM	1/2	24
16-QAM	3/4	36
64-QAM	1/2	48
64-QAM	2/3	48
64-QAM	3/4	54
64-QAM	5/6	54
256-QAM	3/4	54
256-QAM	5/6	54
1024-QAM	3/4	54
1024-QAM	5/6	54

NOTE—In a TVWS band, the non-HT reference rate is scaled as described in 22.2.4 (Support for NON_HT and HT formats).

10.9 HT Control field operation

Change 10.9 as follows:

If the value of dot11HTControlFieldSupported is true, a STA shall set the +HTC Support subfield of the HT Extended Capabilities field of the HT Capabilities element to 1 in HT Capabilities elements that it transmits. If the value of dot11VHTControlFieldOptionImplemented is true, a STA shall set the +HTC-VHT Support subfield of the VHT Capabilities Information field of the VHT Capabilities element to 1 in VHT Capabilities elements that it transmits. If dot11HEControlFieldOptionImplemented is true, a STA shall set the +HTC-HE Support subfield of the HE Capabilities Information field of the HE Capabilities element to 1 in HE Capabilities elements that it transmits.

A STA that has a value of true for at least one of dot11RDResponderOptionImplemented, dot11MCSFeedbackOptionImplemented, and dot11AlternateEDCAActivated shall set dot11HTControlFieldSupported or dot11VHTControlFieldOptionImplemented or both to true. A STA for which at least one of dot11HEULMUResponseSchedulingOptionImplemented, dot11HEMCSFeedbackOptionImplemented, dot11OMIOptionImplemented, dot11HEBSRControlImplemented, dot11HEUPHControlActivated, dot11HEBQRControlImplemented, or dot11HECASControlImplemented is true shall set dot11HEControlFieldOptionImplemented to true.

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An HT variant HT Control field shall not be present in a frame addressed to a STA unless that STA declares support for +HTC-HT in the HT Extended Capabilities field of its HT Capabilities element (see 9.2.4.6 (HT Control field)).

A VHT variant HT Control field shall not be present in a frame addressed to a STA unless that STA declares support for +HTC-VHT in the VHT Capabilities Information field of its VHT Capabilities element or in the S1G Capabilities Information field of S1G Capabilities elements that it transmits.

NOTE–An HT STA that does not support +HTC (HT or VHT variant) that receives a +HTC frame addressed to another STA still performs the CRC on the actual length of the MPDU and uses the Duration/ID field to update the NAV, as described in 10.3.2.4 (Setting and resetting the NAV).

An HE variant HT Control field shall not be present in a frame addressed to a STA unless that STA declares support for +HTC-HE in the HE MAC Capabilities Information field of the HE Capabilities element. The HE variant HT Control field carried in the frame may contain a Control subfield supported by the intended receiver that has:

- A value of 0 in the Control ID subfield when the transmitting STA expects an HE TB PPDU that follow the UMRS information as described in 27.5.3.2 (Rules for soliciting UL MU frames).
- A value of 1 in the Control ID subfield when the transmitting STA changes its operating mode, as described in 27.8 (Operating mode indication).
- A value of 2 in the Control ID subfield when the transmitting STA follows the HE link adaptation procedure, as described in 27.13 (Link adaptation using the HLA Control field).
- A value of 3 in the Control ID subfield when the transmitting STA follows the corresponding buffer status report procedure, as described in 27.5.3.6 (HE buffer status feedback operation for UL MU)
- A value of 4 in the Control ID subfield when the transmitting STA follows the UL MU operation procedure, as described in 27.5.3.3 (STA behavior for UL MU operation).
- A value of 5 in the Control ID subfield when the transmitting STA follows the bandwidth query report procedure, as described in 27.5.2 (HE bandwidth query report operation for MU).
- A value of 6 in the Control ID subfield when the transmitting STA follows the reverse direction protocol procedure as described in 10.28 (Reverse Direction Protocol).

If the HT Control field is present in an MPDU aggregated in an A-MPDU, then all MPDUs of the same frame type (i.e., having the same value for the Type subfield of the Frame Control field) aggregated in the same A-MPDU shall contain an HT Control field. The HT Control field of all MPDUs containing the HT Control field aggregated in the same A-MPDU shall be set to the same value.

If an A-Control subfield is present in a frame then it shall contain at least one Control subfield, and the Control subfield shall be present in the A-Control subfield only if it is supported by the receiving STAs; otherwise it shall not be present. An HE STA that receives an A-Control subfield shall ignore a Control field with a Control ID subfield whose value is not recognized or is not supported by the STA. For any Control ID value only one Control subfield shall be present in the A-Control subfield of QoS Data, QoS Null, or Management frames carried in an (A-)MPDU.

NOTE—An A-Control field that is present in a frame cannot contain only the Padding subfield.

If the HT variant HT Control field is present in an MPDU, the DEI subfield provides information on the drop eligibility of the contents of the received MPDU. When there are insufficient resources in a STA, the STA arbitrarily discards frames in order to recover from the lack of resources. With the information from the DEI subfield, a STA may selectively drop frames with the DEI subfield set to 1 in preference to frames with the DEI subfield set to 0, if resources are insufficient. Note that this might not help in the recovery in all conditions, and the STA might still have to fall back to the arbitrary discard strategy. The mechanisms for determining whether resources are insufficient or when to discard MSDUs or A-MSDUs are beyond the scope of this standard.

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If the value of dot11S1GControlFieldOptionImplemented is true, an S1G STA shall set the +HTC-VHT Capable subfield of the S1G Capabilities Information field of the S1G Capabilities element that it transmits to 1.

10.10 Control Wrapper operation

Change as follows:

A STA supporting the HT Control field that receives a Control Wrapper frame shall process it as though it received a frame of the subtype of the wrapped frame. An HE STA shall not send a Control Wrapper frame to another HE STA.

10.12 A-MSDU operation

Change the 3rd paragraph as follows:

If a recipient has not indicated support for the reception of fragmented A-MSDUs, then an ~~An~~ A-MSDU shall be carried, without fragmentation, within a single QoS Data frame. If a recipient has indicated support for the reception of fragmented A-MSDU, then an A-MSDU may be fragmented and each fragment sent to the recipient in a QoS Data frame. Support for the reception of fragmented A-MSDUs is indicated with the A-MSDU Fragmentation Support field in the HE Capabilities element.

Change the 8th paragraph as follows:

A STA shall support the reception of an A-MSDU, where the A-MSDU is carried in a QoS Data frame with Ack Policy equal to Normal Ack in the following cases:

— By an HT STA when the A-MSDU is not aggregated within an A-MPDU

— By a VHT or HE STA when the A-MSDU is sent as an S-MPDU

Insert the following after the 9th paragraph:

An HE STA shall not transmit an A-MSDU that is carried in a QoS Data frame for which no block ack agreement exists and that is part of an ack-enabled A-MPDU unless the recipient indicates support for A-MSDU by setting the A-MSDU In A-MPDU Supported subfield in the HE MAC Capabilities Information field of the HE Capabilities element to 1.

10.13 A-MPDU operation

10.13.1 A-MPDU contents

Change the 2nd paragraph as follows:

When an A-MPDU contains multiple QoS Control fields, bits ~~4~~ 4 shall be identical across all MPDUs that contain the QoS Control fields and bits 8–15 of these QoS Control fields shall be identical across all MPDUs with equal value of the TID subfield.

10.13.2 A-MPDU length limit rules

Change as follows:

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A STA indicates in the Maximum A-MPDU Length Exponent field in its HT Capabilities element the maximum A-MPDU length that it can receive in an HT PPDU. A STA indicates in the Maximum A-MPDU Length Exponent field in its VHT Capabilities element the maximum length of the A-MPDU pre-EOF padding that it can receive in a VHT PPDU. A DMG STA indicates in the Maximum A-MPDU Length Exponent field in its DMG Capabilities element the maximum A-MPDU length that it can receive. A STA indicates in the Maximum A-MPDU Length Exponent field in its HT Capabilities, VHT Capabilities and HE Capabilities elements the maximum length of the A-MPDU pre-EOF padding that it can receive in an HE PPDU. The encoding of these fields is defined in Table 9-163 (Subfields of the A-MPDU Parameters field) for an HT PPDU and HE PPDU, in Table 9-249 (Subfields of the VHT Capabilities Information field) for a VHT PPDU and HE PPDU, ~~and~~ in Table 9-229 (Subfields of the A-MPDU Parameters subfield) for a DMG STA, and in 9.4.2.237 (HE Capabilities element).

A VHT STA that sets the Maximum A-MPDU Length Exponent field in its VHT Capabilities element to a value in the range 0 to 3 shall set the Maximum A-MPDU Length Exponent in its HT Capabilities to the same value. A VHT STA that sets the Maximum A-MPDU Length Exponent field in the VHT Capabilities element to a value larger than 3 shall set the Maximum A-MPDU Length Exponent in its HT Capabilities element to 3.

Using the Maximum A-MPDU Length Exponent fields in the HT Capabilities~~, and~~ VHT Capabilities, and HE Capabilities elements, the STA establishes at association the maximum length of an A-MPDU pre-EOF padding that can be sent to it. An HT STA shall be capable of receiving A-MPDUs of length up to the value indicated by the Maximum A-MPDU Length Exponent field in its HT Capabilities element. A VHT STA shall be capable of receiving A-MPDUs where the A-MPDU pre-EOF padding length is up to the value indicated by the Maximum A-MPDU Length Exponent field in its VHT Capabilities element. An HE STA shall be capable of receiving A-MPDUs where the A-MPDU pre-EOF padding length is up to the value indicated by the Maximum A-MPDU Length Exponent field in its HT Capabilities, VHT Capabilities and HE Capabilities elements.

A STA shall not transmit an A-MPDU in an HT PPDU that is longer than the value indicated by the Maximum A-MPDU Length Exponent field in the HT Capabilities element received from the intended receiver. MPDUs in an A-MPDU carried in an HT PPDU shall be limited to a maximum length of 4095 octets. A STA shall not transmit an A-MPDU in a VHT PPDU where the A-MPDU pre-EOF padding length is longer than the value indicated by the Maximum A-MPDU Length Exponent field in the VHT Capabilities element received from the intended receiver. A DMG STA shall not transmit an A-MPDU that is longer than the value indicated by the Maximum A-MPDU Length Exponent field in the DMG Capabilities element received from the intended receiver. A STA shall not transmit an A-MPDU in an HE PPDU where the A-MPDU pre-EOF padding length is longer than the value indicated by the Maximum A-MPDU Length Exponent field in the HT Capabilities, VHT Capabilities and HE Capabilities elements received from the intended receiver.

Change the title and content of 10.13.3 as follows:

10.13.3 Minimum MPDU ~~S~~start ~~S~~spacing ~~field~~ rules

If the intended receiver is a non-HE STA, a ~~A~~ STA shall not start the transmission of more than one MPDU within the time limit described in the Minimum MPDU Start Spacing field declared by the intended receiver. If the intended receiver is an HE STA, an HE STA shall not start the transmission of more than one QoS Data frame, QoS Null frame or Management frame within the time limit described in the Minimum MPDU Start Spacing field declared by the intended receiver. To satisfy this requirement, the number of octets between the start of two consecutive MPDUs in an A-MPDU, measured at the PHY SAP, shall be equal to or greater than

$$t_{MMSS} \times r / 8$$

where

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t_{MMSS} is the time (in microseconds) defined in the "Encoding" column of Table 9-163 for an HT STA and of Table 9-229 (Subfields of the A-MPDU Parameters subfield) for a DMG STA for the value of the Minimum MPDU Start Spacing field and if the A-MPDU is carried in an HE TB PPDU sent in response to a Basic Trigger frame, then the time provided in of Table 9-163 shall be multiplied by $2^{\text{MPDU MU Spacing Factor}}$ where the exponent is the value of the MPDU MU Spacing Factor subfield of the User Info field addressed to the HE STA (see 9.3.1.23 (Trigger frame format)).

r is the value of the PHY Data Rate (in megabits per second) defined in 19.5 (Parameters for HT MCSs) for HT PPDUs, in 21.5 (Parameters for VHT-MCSs) for VHT PPDUs, and in Clause 20 (Directional multi-gigabit (DMG) PHY specification) for a DMG STA

If necessary, in order to satisfy this requirement, a STA shall add padding between MPDUs in an A-MPDU. Any such padding shall be in the form of one or more MPDU delimiters with the MPDU Length field set to 0.

QoS Null frames transmitted by DMG STAs are not subject to this spacing, i.e., no MPDU delimiters with zero length need to be inserted after the MPDU immediately preceding the QoS Null frame in an A-MPDU.

10.22 HCF

10.22.1 General

Change the 3rd paragraph as follows:

HCCA is not used by DMG and HE STAs.

10.22.2 HCF contention based channel access (EDCA)

10.22.2.2 EDCA backoff procedure

Change the last paragraph as follows:

If the backoff procedure is invoked for reason c), d), e) or f) above, or the transmission failure of a non-initial frame by the TXOP holder, the value of CW[AC] shall be updated as follows before invoking the backoff procedure:

- If the QSRC[AC] or the QLRC[AC] has reached dot11ShortRetryLimit or dot11LongRetryLimit respectively, CW[AC] shall be reset to CWmin[AC].
- If dot11RobustAVStreamingImplemented is true and either the QSDRC[AC] or the QLDRC[AC] has reached dot11ShortDEIRetryLimit or dot11LongDEIRetryLimit, respectively, CW[AC] shall be reset to CWmin[AC].
- Otherwise,
  - If CW[AC] is less than CWmax[AC], CW[AC] shall be set to the value (CW[AC] + 1) × 2 – 1.
  - If CW[AC] is equal to CWmax[AC], CW[AC] shall be left unchanged.

NOTE—An HE STA updates its local MIB variables related to CWmin and CWmax as defined in 10.2.4.2 (HCF contention based channel access (EDCA)) and in 27.2.6 (Obtaining an EDCA TXOP for HE non-AP STAs using MU EDCA parameters).

Insert the following at the end of subclause 10.22.2.2:

An HE STA resumes the EDCA backoff procedure without modifying CW or the backoff counter for the associated EDCAF, after transmission of an MPDU in an HE TB PPDU regardless of whether the STA has received the corresponding acknowledgement frame in response to the MPDU sent in the HE TB PPDU.

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10.22.2.4 Obtaining an EDCA TXOP

Change the last paragraph and insert a new paragraph as follows:

A STA shall save the TXOP holder address for the BSS in which it is associated, which is the MAC address from the Address 2 field of the frame that initiated a frame exchange sequence except when this is a CTS frame, in which case the TXOP holder address is the Address 1 field. If the TXOP holder address is obtained from a Control frame, a VHT STA or HE STA shall save the nonbandwidth signaling TA value obtained from the Address 2 field. If a non-VHT non-HE STA receives an RTS frame with the RA address matching the MAC address of the STA and the MAC address in the TA field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regard for, and without resetting, its NAV. If a VHT STA or HE STA receives an RTS frame with the RA address matching the MAC address of the STA and the nonbandwidth signaling TA value obtained from the Address 2 field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regard for, and without resetting, its NAV. When a STA receives a frame addressed to it that requires an immediate response, except for RTS and Trigger frames (see 27.5.3.5 (UL MU CS mechanism)), it shall transmit the response independent of its NAV. The saved TXOP holder address shall be cleared when the NAV is reset or when the NAV counts down to 0.

During an EDCA TXOP, the Address 2 field excluding the Individual/Group bit of all control frames sent by a TXOP holder shall be set to the same address value.

Change the title of subclause 10.22.2.5 as follows:

10.22.2.5 EDCA channel access in a VHT, HE or TVHT BSS

Change Table 10-10 as follows:

Table 10-10—Channels indicated idle by the channel-list parameter

PHY-CCA.indication primitive channel-list element	Idle channels
primary	None
secondary	Primary 20 MHz channel
secondary40	Primary 20 MHz channel and secondary 20 MHz channel
secondary80	Primary 20 MHz channel, secondary 20 MHz channel, and secondary 40 MHz channel
per20MHzbitmap	Each bit of the per20MHzbitmap that is equal to 0 indicates an idle channel (see 28.3.17.6.5 (Per-20MHz CCA sensitivity))

Change 4th paragraph as follows:

If a STA is permitted to begin a TXOP (as defined in 10.22.2.4 (Obtaining an EDCA TXOP)) and the STA has at least one MSDU pending for transmission for the AC of the permitted TXOP, the STA shall perform exactly one of the following actions:

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a) Transmit a 160 MHz or 80+80 MHz mask PPDU if the secondary channel, the secondary 40 MHz channel, and the secondary 80 MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.

b) Transmit an 80 MHz mask PPDU on the primary 80 MHz channel if both the secondary channel and the secondary 40 MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.

c) Transmit a 40 MHz mask PPDU on the primary 40 MHz channel if the secondary channel was idle during an interval of PIFS for the 5 GHz band or DIFS for an HE STA operating in the 2.4 GHz band immediately preceding the start of the TXOP.

d) Transmit a 20 MHz mask PPDU on the primary 20 MHz channel.

e) Restart the channel access attempt by invoking the backoff procedure as specified in 10.22.2 (HCF contention based channel access (EDCA)) as though the medium is busy on the primary channel as indicated by either physical or virtual CS and the backoff timer has a value of 0.

f) Transmit a TVHT_4W or TVHT_2W+2W mask PPDU if the secondary TVHT_W channel and the secondary TVHT_2W channel were idle during an interval of PIFS immediately preceding the start of the TXOP.

g) Transmit a TVHT_2W or TVHT_W+W mask PPDU if the secondary TVHT_W channel was idle during an interval of PIFS immediately preceding the start of the TXOP.

h) Transmit a TVHT_W mask PPDU on the primary TVHT_W channel.

i) Transmit an HE MU PPDU with preamble puncturing in 80 MHz where in the preamble only the secondary 20 MHz is punctured if the primary 20 MHz channel and the secondary 40MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.

j) Transmit an HE MU PPDU with preamble puncturing in 80 MHz where in the preamble only one of the two 20 MHz subchannels in the secondary 40 MHz is punctured if the primary 20 MHz channel, the secondary 20 MHz channel, and one of the two 20 MHz subchannels of the secondary 40 MHz were idle during an interval of PIFS immediately preceding the start of the TXOP.

k) Transmit an HE MU PPDU with preamble puncturing in 160 MHz or 80+80 MHz where in the primary 80 MHz of the preamble only the secondary 20 MHz is punctured if the primary 20 MHz channel, the secondary 40 MHz channel, and at least one of the four 20 MHz subchannels in the secondary 80 MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.

l) Transmit an HE MU PPDU with preamble puncturing in 160 MHz or 80+80 MHz where in the primary 80 MHz of the preamble only the primary 40 MHz is present if the primary 20 MHZ channel, the secondary 20 MHz channel, and at least one of the four 20 MHz subchannels in the secondary 80 MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.

NOTE 1—In the case of rule e), the STA selects a new random number using the current value of CW[AC], and the retry counters are not updated (as described in 10.22.2.7 (Multiple frame transmission in an EDCA TXOP); backoff procedure invoked for event a)).

NOTE 2— ~~For both an HT, and a VHT STA, an EDCA TXOP is obtained~~ An HT, VHT or HE STA obtains an EDCA TXOP based on activity on the primary channel (see 10.22.2.4 (Obtaining an EDCA TXOP)). The width of transmission is determined by the CCA status of the nonprimary channels during the PIFS interval for the 5 GHz band or DIFS interval for an HE STA operating in the 2.4 GHz band before transmission (see ~~VHT description in~~ 10.3.2 (Procedures common to the DCF and EDCAF)).

NOTE 3—In the case of rule j), there is only one idle 20 MHz subchannel in the secondary 40 MHz channel and the other 20 MHz subchannel in the secondary 40 MHz is preamble punctured.

10.22.2.6 Sharing an EDCA TXOP

Change the 1st three paragraphs as follows:

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This mode applies only to an AP that supports DL-MU-MIMO or DL OFDMA. The AC associated with the EDCAF that gains an EDCA TXOP becomes the primary AC. TXOP sharing is allowed when primary AC traffic is transmitted in a VHT MU PPDU or an HE MU PPDU and resources permit traffic from secondary ACs to be included, targeting up to four STAs if it is transmitted in a VHT MU PPDU. The inclusion of secondary AC traffic in a VHT MU PPDU shall not increase the duration of the VHT MU PPDU beyond that required to transport the primary AC traffic. The inclusion of secondary AC traffic in an HE MU PPDU is described in 10.22.2.7 (Multiple frame transmission in an EDCA TXOP). If a destination in a VHT MU PPDU is targeted by frames in the queues of both the primary AC and at least one secondary AC, the frames in the primary AC queue shall be transmitted to the destination first, among a series of downlink transmissions within a TXOP. The decision of which secondary ACs and destinations are selected for TXOP sharing, as well as the order of transmissions, are implementation specific and out of scope of this standard. The inclusion of secondary AC traffic in an HE MU PPDU shall not cause the TXOP limit of the primary AC to be exceeded.

When sharing, the TXOP limit that applies is the TXOP limit of the primary AC.

NOTE—An AP can protect an immediate response by preceding the VHT MU PPDU or the HE MU PPDU (which might have TXVECTOR parameter NUM_USERS > 1) with an RTS/CTS exchange or an MU-RTS/CTS exchange or a CTS-to-self transmission.

10.22.2.7 Multiple frame transmission in an EDCA TXOP

Change the 1st paragraph as follows:

A frame exchange, in the context of multiple frame transmission in an EDCA TXOP, may be one of the following:

- A frame not requiring immediate acknowledgment (such as a group addressed frame or a frame transmitted with an acknowledgment policy that does not require immediate acknowledgment) or an A-MPDU containing only such frames
- A frame requiring acknowledgment (such as an individually addressed frame transmitted with an acknowledgment policy that requires immediate acknowledgment) or an A-MPDU containing at least one such frame, followed after SIFS by a corresponding acknowledgment frame
- A frame soliciting an HE TB PPDU (such as a Trigger frame or a frame carrying an UL MU Response Scheduling A-Control subfield) or an A-MPDU containing at least one such frame, followed after SIFS by an HE TB PPDU
- Either
  - a VHT NDP Announcement frame followed after SIFS by a VHT NDP followed after SIFS by a PPDU containing one or more VHT Compressed Beamforming frames, or
  - a Beamforming Report Poll frame followed after SIFS by a PPDU containing one or more VHT Compressed Beamforming frames
  - an HE NDP Announcement frame followed after SIFS by an HE NDP followed after SIFS by a PPDU containing one or more HE Compressed Beamforming frames, or
  - an HE NDP Announcement frame followed after SIFS by an HE NDP, or
  - a BRP Trigger frame followed after SIFS by an HE TB PPDU containing one or more HE Compressed Beamforming And CQI frames

A DL MU PPDU may carry MPDUs addressed to multiple recipients, hence multiple frame exchanges are performed simultaneously. If at least one of those frame exchanges requires an immediate response (i.e., the AP includes at least one Trigger frame or UMRS Control field) and if the AP receives an immediate response with at least one correct MPDU from at least one of the solicited STAs, the rules in this subclause apply.

Change the paragraphs 7 - 9 as follows:

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If a TXOP is protected by an RTS or CTS frame carried in a non-HT or a non-HT duplicate PPDU, the TXOP holder shall set the TXVECTOR parameter CH_BANDWIDTH of a PPDU as follows:

— To be the same or narrower than the RXVECTOR parameter CH_BANDWIDTH_IN_NON_HT of the last received CTS frame in the same TXOP, if the RTS frame with a bandwidth signaling TA and TXVECTOR parameter DYN_BANDWIDTH_IN_NON_HT set to Dynamic has been sent by the TXOP holder in the last RTS/CTS exchange.

— Otherwise, to be the same or narrower than the TXVECTOR parameter CH_BANDWIDTH of the RTS frame that has been sent by the TXOP holder in the last RTS/CTS exchange in the same TXOP.

If a TXOP is protected by an MU-RTS or CTS frame carried in a non-HT or a non-HT duplicate PPDU, the TXOP holder shall set the TXVECTOR parameter CH_BANDWIDTH of a PPDU as follows:

— To be the same or narrower than the TXVECTOR parameter CH_BANDWIDTH of the MU-RTS Trigger frame that has been sent by the TXOP holder in the last MU-RTS/CTS exchange in the same TXOP, if the RU Allocation subfields of the MU-RTS Trigger frame for all intended receivers are equal to a value that corresponds to the channel bandwidth that is indicated in the BW subfield in the Common Info field of the MU-RTS Trigger frame.

— Otherwise, to be the same or narrower than the TXVECTOR parameter CH_BANDWIDTH of the preceding PPDU that it has transmitted in the same TXOP.

If there is no RTS/CTS or MU-RTS/CTS exchange in non-HT duplicate format in a TXOP, and the TXOP includes at least one non-HT duplicate frame exchange that does not include a PS-Poll, then the TXOP holder shall set the CH_BANDWIDTH parameter in TXVECTOR of a PPDU sent after the first non-HT duplicate frame that is not a PS-Poll to be the same or narrower than the CH_BANDWIDTH parameter in TXVECTOR of the initial frame in the first non-HT duplicate frame exchange in the same TXOP.

If there is no non-HT duplicate frame exchange in a TXOP, the TXOP holder shall set the TXVECTOR parameter CH_BANDWIDTH of a non-initial PPDU to be the same or narrower than the TXVECTOR parameter CH_BANDWIDTH of the preceding PPDU that it has transmitted in the same TXOP, subject to the following constraints:

— If the preceding PPDU is an HE DL MU PPDU with preamble puncture, the TXOP holder shall set the TXVECTOR parameter CH_BANDWIDTH of the non-initial PPDU to a value whose corresponding 20 MHz channels are within a set of 20 MHz channels where pre-HE modulated fields of the preceding PPDU are located.

— If the non-initial PPDU is an HE DL MU PPDU with preamble puncture, the TXOP holder shall set the TXVECTOR parameter RU_ALLOCATION of the non-initial PPDU to a value whose corresponding RU is within a set of 20 MHz channels where pre-HE modulated fields of the preceding PPDU are located.

10.22.2.8 TXOP limits

Change the subclause as follows:

The duration of a TXOP is the time a STA obtaining a TXOP (the TXOP holder) maintains uninterrupted control of the medium, and it includes the time required to transmit frames sent as an immediate response to TXOP holder transmissions. The TXOP holder shall, subject to the exceptions below, ensure that the duration of a TXOP does not exceed the TXOP limit, when nonzero.

The TXOP limits are advertised by the AP in the EDCA Parameter Set element in Beacon and Probe Response frames transmitted by the AP.

A TXOP limit of 0 indicates that the TXOP holder may transmit or cause to be transmitted (as responses) the following within the current TXOP:

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a) One of the following at any rate, subject to the rules in 10.7 (Multirate support)
   1) One or more SU PPDUs carrying fragments of a single MSDU or MMPDU
   2) An SU PPDU or a VHT MU PPDU or an HE MU PPDU or an HE TB PPDU carrying a single MSDU, a single MMPDU, a single A-MSDU, or a single A-MPDU
   3) A VHT MU PPDU or an HE MU PPDU carrying A-MPDUs to different users (a single A-MPDU to each user)
   4) A QoS Null frame or PS-Poll frame
   5) A Basic Trigger frame, BSRP Trigger frame or BQRP Trigger frame
   6) An HE TB PPDU carrying A-MPDUs from different users (a single A-MPDU from each user)
b) Any required acknowledgments
c) Any frames required for protection, including one of the following:
   1) An RTS/CTS or MU-RTS/CTS exchange
   2) CTS to itself
   3) Dual CTS as specified in 10.3.2.8 (Dual CTS protection)
d) Any frames required for beamforming as specified in 10.30 (Sounding PPDUs), 10.34.5 (VHT sounding protocol), 27.6 (HE sounding protocol) and 10.38 (DMG beamforming).
e) Any frames required for link adaptation as specified in 10.31 (Link adaptation) and 27.13 (Link adaptation using the HE variant HT Control field).
f) Any number of BlockAckReq, MU-BAR Trigger or Multi-TID BlockAckReq or a GCR MU-BAR Trigger frames

NOTE 1—This is a rule for the TXOP holder. A TXOP responder need not be aware of the TXOP limit nor of when the TXOP was started.

NOTE 2—This rule prevents the use of RD when the TXOP limit is 0.

When dot11OCBActivated is true, TXOP limits shall be 0 for each AC.

The TXOP holder may exceed the TXOP limit only if it does not transmit more than one Data or Management frame in the TXOP, and only for the following situations:

— Retransmission of an MPDU, not in an A-MPDU consisting of more than one MPDU
— Initial transmission of an MSDU under a block ack agreement, where the MSDU is not in an AMPDU consisting of more than one MPDU and the MSDU is not in an A-MSDU
— Transmission of a Control MPDU or a QoS Null MPDU, not in an A-MPDU consisting of more than one MPDU
— Initial transmission of a fragment of an MSDU or MMPDU, if the fragment is not a dynamic fragment and a previous fragment of that MSDU or MMPDU was retransmitted
— Transmission of a fragment of an MSDU or MMPDU fragmented into 16 fragments if the fragment is not a dynamic fragment
— Transmission of the 16th fragment of an MSDU or MMPDU or A-MSDU under dynamic fragmentation
— Initial transmission of the first fragment of an MSDU or MMPDU or A-MSDU under dynamic fragmentation, where the size of the first fragment is equal to the minimum fragment size specified by the receiver STA and the MSDU or MMPDU or A-MSDU is not in an A-MPDU consisting of more than one MPDU
— Transmission of an A-MPDU consisting of the initial transmission of a single MPDU not containing an MSDU and that is not an individually addressed Management frame
— Transmission of a group addressed MPDU, not in an A-MPDU consisting of more than one MPDU
— Transmission of a null data packet (NDP)

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— Transmission of a VHT NDP Announcement frame and NDP or transmission of a Beamforming Report Poll frame, where these fit within the TXOP limit and it is only the response and the immediately preceding SIFS that cause the TXOP limit to be exceeded.

— Transmission of an HE NDP Announcement frame and NDP or transmission of an HE NDP Announcement frame and NDP and BRP Trigger frame or transmission of a BRP Trigger frame, where these fit within the TXOP limit and it is only the response and the immediately preceding SIFS that cause the TXOP limit to be exceeded.

Except as described above, a STA shall fragment an individually addressed MSDU or MMPDU so that the initial transmission of the first fragment does not cause the TXOP limit to be exceeded.

NOTE—The TXOP limit is not exceeded for the following situations:

— Initial transmission of an MPDU containing an unfragmented though fragmentable (see 10.2.7 and 27.3 (Fragmentation and defragmentation)) MSDU/MMPDU

— Initial transmission of the first fragment of a fragmented MSDU/MMPDU, except ~~for an~~ when the MSDU/MMPDU is fragmented into 16 fragments and the fragment is not a dynamic fragment

— Initial transmission of an A-MSDU

— Initial transmission of a fragment of a fragmented MSDU/MMPDU, if no previous fragment of that MSDU/MMPDU was retransmitted, except ~~for an~~ when the MSDU/MMPDU is fragmented into 16 fragments and the fragments is not a dynamic fragment

— Initial transmission of a fragment of a fragmented MSDU/MMPDU/A-MSDU under dynamic fragmentation, except for, either the first fragment of a fragmented MSDU/MMPDU/A-MSDU using the minimum fragment size specified by the receiver STA, or the 16th fragment of a fragmented MSDU/MMPDU/A-MSDU

— Transmission of an A-MPDU consisting of a single MPDU containing an A MSDU or individually addressed Management frame, unless this is a retransmission of that MPDU

— Transmission of an A-MPDU consisting of more than one MPDU, even if some or all of the MPDUs are retransmissions

If the TXOP holder exceeds the TXOP limit, it should use as high a PHY rate as possible to minimize the duration of the TXOP.

The duration of a TXOP for a mesh STA that has dot11MCCAActivated true shall not exceed the time between the start of the TXOP and the end of the current MCCAOP reservation.

NOTE—The rules in this subclause also apply to priority-downgraded MSDUs and A-MSDUs (see 10.22.4.2).

When the Duration field value in the MAC header of an HE TB PPDU is set to 0, the HE TB PPDU shall not include any frames that solicit a control response frame from the AP.

10.22.2.9 Truncation of TXOP

Insert the following at the end of the subclause:

An HE STA that receives a CF-End frame resets its NAV unless either of following conditions are met:

— The received CF-End frame is an inter-BSS frame and the most recent NAV update was due to an intra-BSS frame (see 27.2.2 (Intra-BSS and inter-BSS frame determination)).

— The received CF-End frame is an intra-BSS frame and the most recent NAV update was due to an inter-BSS frame (see 27.2.2 (Intra-BSS and inter-BSS frame determination)).

NOTE 1—For HE STAs with two NAVs, the TXOP truncation rule applies to each NAV separately.

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10.22.2.10 Termination of TXOP

Change Table 10-11 as follows:

Table 10-11—Modulation classes eligible for TXOP termination

Modulation classes eligible for TXOP termination (see Table 10-6)
DSSS
HR/DSSS
ERP-OFDM
OFDM (20 MHz channel spacing)
HT
VHT
HE

Change Table 10-12 as follows:

Table 10-12—Rate and modulation class of a final transmission in a TXOP

Modulation class and data rate of immediately preceding frame in TXOP	Rate and modulation class of final transmission
DSSS or HR/DSSS with long preamble, data rate > 1 Mb/s	1 Mb/s DSSS
HR/DSSS with short preamble, data rate > 2 Mb/s	2 Mb/s HR/DSSS short preamble
Other eligible modulation classes, ~~data rate > 6 Mb/s~~ except 6 Mb/s OFDM	6 Mb/s OFDM

10.22.2.11 Retransmit procedures

10.22.2.11.1 General

Insert the following at the end of the subclause:

If an HE STA transmits an HE TB PPDU, the QSRC[AC] and QLRC[AC] for the associated EDCAF are not changed.

10.22.4 Admission Control at the HC

10.22.4.2 Contention based admission control procedures

10.22.4.2.3 Procedure at non-AP STAs

Change the 8th paragraph as follows:

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The MPDUExchangeTime equals the time required to transmit the MPDU sequence. For the case of an MPDU transmitted with Normal Ack policy and without RTS/CTS protection, this equals the time required to transmit the MPDU plus the time required to transmit the expected response frame plus one SIFS. Frame exchange sequences for Management frames and the HE TB PPDU are excluded from the used_time update. If the used_time value reaches or exceeds the admitted_time value, the corresponding EDCAF shall no longer transmit QoS Data frames or QoS Null MPDUs using the EDCA parameters for that AC as specified in the QoS Parameter Set element. However, a STA may choose to temporarily replace the EDCA parameters for that EDCAF with those specified for an AC of lower priority, if no admission control is required for those ACs.

10.24 Block acknowledgement (block ack)

10.24.2 Setup and modification of the block ack parameters

Change the 6th paragraph as follows:

When a block ack agreement is established between two HT STAs or two DMG STAs, the originator may change the size of its transmission window if the value in the Buffer Size field of the ADDBA Response frame is larger than the value in the ADDBA Request frame. ~~If the value in the Buffer Size field of the ADDBA Response frame is smaller than the value in the ADDBA Request frame, the originator shall change the size of its transmission window (WinSizeO) so that it is not greater than the value in the Buffer Size field of the ADDBA Response frame and is not greater than the value 64.~~ If the value in the Buffer Size field of the ADDBA Response frame is smaller than the value in the ADDBA Request frame, the originator shall change the size of its transmission window (WinSizeO) so that it is not greater than the value in the Buffer Size field of the ADDBA Response frame and is not greater than the value 64 if the sender of the ADDBA Response frame is a non-HE STA and not greater than 256 if the sender of the ADDBA Response frame is an HE STA.

10.24.6 Selection of BlockAck and BlockAckReq variants

Change as follows:

The Compressed Bitmap subfield of the ~~BA Control field or~~ BAR Control field shall be set to 1 in all ~~Block-Ack and~~ BlockAckReq frames sent from one HT STA to another HT STA and shall be set to 0 otherwise. The B2 bit of the BA Type subfield of the BA Control field shall be set to 1 in all BlockAck frames sent from one HT STA to another HT STA and shall be set to 0 otherwise. The B1 bit of the BA Type ~~Multi-TID~~ subfield of the BA Control field shall be set to 1 in all BlockAck frames related to an HT-immediate agreement transmitted inside a PSMP sequence and shall be set to 0 otherwise. The Multi-TID subfield of the BAR Control field shall be set to 1 in all BlockAckReq frames related to an HT-immediate agreement transmitted inside a PSMP sequence and shall be set to 0 otherwise.

In a DMG BSS, if the Compressed Bitmap subfield of the BAR Control field within a BlockAckReq frame related to an HT-immediate agreement is equal to 1, then all of the following BlockAck and BlockAckReq frames transmitted as part of the HT-immediate agreement shall have the Compressed Bitmap subfield of the BA Control and BAR Control fields set to 1. In this case, the Multi-TID subfield of the BA Control field and BAR Control field shall be set to 0 in all BlockAck and BlockAckReq frames transmitted as part of the HT-immediate agreement. In a DMG BSS, if the Compressed Bitmap subfield of the BAR Control field within a BlockAckReq frame related to an HT-immediate agreement is equal to 0, then all of the following BlockAck and BlockAckReq frames transmitted as part of the HT-immediate agreement shall have the Compressed Bitmap subfield of the BA Control and BAR Control fields set to 0. In this case, the Multi-TID subfield of the BA Control field and BAR Control field shall be set to 1 in all BlockAck and BlockAckReq frames transmitted as part of the HT-immediate agreement.

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Where the terms BlockAck and BlockAckReq are used within 10.24.7 and 10.24.8, the appropriate variant according to this subclause (e.g., Compressed, Multi-TID) is referenced by the generic term. The GCR subfield of the BAR Control field shall be set to 1 in all BlockAckReq frames where the block ack agreement is for a group address delivered using the GCR block ack retransmission policy and shall be set to 0 otherwise. The B3-B4 bits of the BA Type ~~GCR~~ subfield of the BA Control field shall be set to 1 in all BlockAck frames where the block ack agreement is for a group address delivered using the GCR block ack retransmission policy and shall be set to 0 otherwise.

10.24.7 HT-immediate block ack extensions

10.24.7.1 Introduction to HT-immediate block ack extensions

Insert the following as the last paragraph in this subclause:

In subclauses 10.24.7.2 to 10.24.7.11, the parameter *BitmapLength* is 64 for a non-HE STA.

10.24.7.3 Scoreboard context control during full-state operation

Change the first paragraph as follows (replace 64 with BitmapLength):

For each HT-immediate block ack agreement that uses full-state operation, a recipient shall maintain a block acknowledgment record as defined in 10.24.3. This record includes a bitmap, indexed by sequence number; a 12-bit unsigned integer starting sequence number, $WinStart_R$, representing the lowest sequence number position in the bitmap; a variable $WinEnd_R$; and the maximum transmission window size, $WinSize_R$, which is set to the smaller of ~~64~~ *BitmapLength* and the value of the Buffer Size field of the associated ADDBA Response frame that established the block ack agreement. $WinEnd_R$ is defined as the highest sequence number in the current transmission window. A STA implementing full-state operation for an HT-immediate block ack agreement shall maintain the block acknowledgment record for that agreement according to the following rules:

10.24.7.5 Generation and transmission of BlockAck frames by an HT STA or DMG STA

Change the 2nd paragraph as follows:

When responding with a BlockAck frame to either a received BlockAckReq frame or a received A-MPDU with Ack Policy equal to Normal Ack (i.e., implicit block ack request) during either full-state operation or partial-state operation, any adjustment to the value of $WinStart_R$ according to the procedures defined within 10.24.7.3 (Scoreboard context control during full-state operation) and 10.24.7.4 (Scoreboard context control during partial-state operation) shall be performed before the generation and transmission of the response BlockAck frame. The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield of the BlockAck frame shall be set to any value in the range ($WinEnd_R$ – ~~63~~ *BitmapLength + 1*) to $WinStart_R$. The values in the recipient's record of status of MPDUs beginning with the MPDU for which the Sequence Number subfield value is equal to $WinStart_R$ and ending with the MPDU for which the Sequence Number subfield value is equal to $WinEnd_R$ shall be included in the bitmap of the BlockAck frame.

Change the 4th paragraph as follows:

When responding with a BlockAck frame to either a received BlockAckReq frame or a received A-MPDU with Ack Policy equal to Normal Ack (i.e., implicit block ack request) during either full-state or partial-state operation, if the adjusted value of $WinEnd_R$ is less than the value of the starting sequence number of the BlockAck frame plus ~~63~~ *BitmapLength – 1*, within the bitmap of the BlockAck frame, the status of MPDUs with sequence numbers that are greater than the adjusted value of $WinEnd_R$ shall be reported as unsuccessfully received (i.e., the corresponding bit in the bitmap shall be set to 0).

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10.24.7.6 Receive reordering buffer control operation

Change the 4th paragraph as follows:

$WinEnd_B$ is initialized to $WinStart_B + WinSize_B - 1$, where $WinSize_B$ is set to the smaller of ~~64~~ *BitmapLength* and the value of the Buffer Size field of the ADDBA Response frame that established the block ack agreement.

10.24.10 GCR and GLK-GCR block ack

10.24.10.1 Introduction

Insert as the last paragraph of 10.24.10.1:

An HE AP shall not send a GCR MU-BAR Trigger frame to a non-AP HE STA if the most recently received Extended Capabilities element from the STA does not indicate support for Robust AV Streaming and Advanced GCR.

10.24.10.3 GCR block ack BlockAckReq and BlockAck frame exchanges

Change the following 2nd and 3rd paragraphs as follows:

When the retransmission policy for a group address is GCR Block Ack, an originator shall not transmit more than the GCR buffer size number of A-MSDUs with RA set to the GCR concealment address and the DA field of the A-MSDU subframe set to the GCR group address before sending a BlockAckReq frame to one of the STAs that has a GCR block ack agreement for this group address. The RA field of the BlockAckReq frame shall be set to the MAC address of the destination STA. Upon reception of the BlockAck frame, an originator may send a BlockAckReq frame to another STA that has a block ack agreement for this group address, and this process may be repeated multiple times. If the originator has a GCR block ack agreement with one or more of the HE STAs for this group address, the originator may send a GCR MU-BAR Trigger frame to one or more of the HE STAs. Upon reception of the BlockAck frame from one or more HE STAs, the originator may send a GCR MU-BAR Trigger frame to one or more other HE STAs that have a GCR block ack agreement, and this process may be repeated multiple times.

NOTE 1—If the originator sends a BlockAckReq frame to a STA with a MAC address that matches the SA in any of the A-MSDUs transmitted during the GCR TXOP, the Block Ack Bitmap subfield does not indicate the MSDUs sourced from this STA. This is because the STA will have discarded all group addressed MPDUs transmitted by the AP that have the source address equal to their MAC address (see 10.3.6 (Group addressed MPDU transfer procedure)).

When a recipient receives a BlockAckReq frame with the GCR Group Address subfield equal to a GCR group address, the recipient shall transmit a BlockAck frame at a delay of SIFS after the BlockAckReq frame. The BlockAck frame acknowledges the STA's reception status of the block of group addressed frames requested by the BlockAckReq frame. When an HE STA receives a GCR MU-BAR Trigger frame with the AID12 subfield set to the 12 LSBs of the AID of the HE STA, the HE STA shall include the BlockAck frame in the HE TB PPDU sent in response to the Trigger frame. The BlockAck frames acknowledge the HE STA's reception status of the block of group addressed frames requested by the GCR MU-BAR Trigger frame.

Figure 10-36 (Example of a frame exchange with GCR block ack retransmission policy) shows an example of a frame exchange when the GCR block ack retransmission policy is used. The AP sends several A-MSDUs using the GCR block ack retransmission policy. The AP then sends a BlockAckReq frame to group member 1 of the GCR group, waits for the BlockAck frame, and then sends a BlockAckReq frame to group member 2. After receiving the BlockAck frame from GCR group member 2, the AP determines whether any A-MSDUs need to be retransmitted and sends additional A-MSDUs (some of which might be retransmissions of previous A-MSDUs) using the GCR block ack retransmission policy.

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Insert the following paragraph and associated figure:

Figure 10-36a (Example of a frame exchange with GCR block ack retransmission policy) shows another example of a frame exchange when the GCR block ack retransmission policy is used. The HE AP sends several A-MSDUs using the GCR block ack retransmission policy. The HE AP then sends a GCR MU-BAR Trigger frame to group members 1 and 2 of the GCR group, waits for the BlockAck frames, and then sends a GCR MU-BAR Trigger frame to group members 3 and 4 and then waits for the BlockAck frames. The HE AP then sends a BlockAckReq frame to group member 5, which is a non-HE STA, and waits for the BlockAck frame. After receiving the BlockAck frames, the HE AP determines whether any A-MSDUs need to be retransmitted and sends additional A-MSDUs (some of which might be retransmissions of previous A-MSDUs) using the GCR block ack retransmission policy.

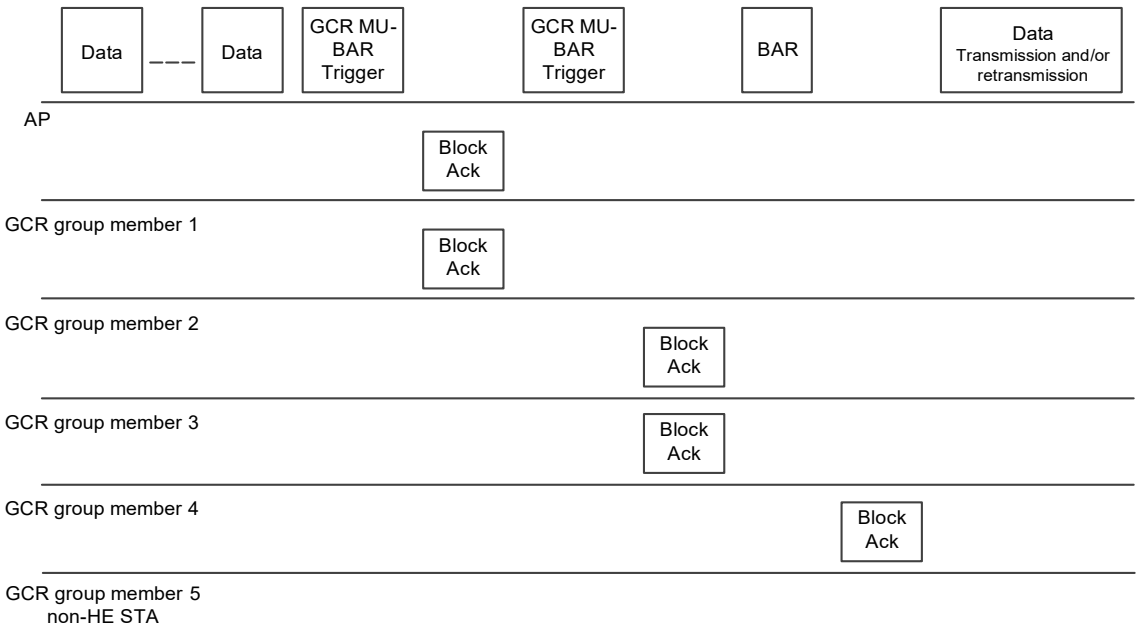


Figure 10-36a—Example of a frame exchange with GCR block ack retransmission policy

Change the 6th,7th and 8th paragraph as follows:

After completing the BlockAckReq or GCR MU-BAR Trigger and BlockAck frame exchanges, the originator determines from the information provided in the BlockAck bitmap and from the missing BlockAck frames which, if any, A-MSDUs need to be retransmitted.

An originator adopting the GCR block ack retransmission policy for a GCR group address chooses a lifetime limit for the group address. The originator may vary the lifetime limit for the group address at any time and may use different lifetime limits for different GCR group addresses. The originator transmits and retries each A-MSDU until the appropriate lifetime limit is reached or until each one has been received by all group members to which a BlockAckReq frame or a GCR MU-BAR Trigger frame has been sent, whichever occurs first.

For GCR streams with retransmission policy equal to GCR Block Ack, an originator may regularly send a BlockAckReq frame with the GCR Group Address subfield in the BAR Information field set to the GCR group address and the Block Ack Starting Sequence Control subfield set to the Sequence Number field of the earliest A-MSDU of the GCR stream that has not been acknowledged by all group members and has not expired due to lifetime limits, in order to minimize buffering latency at receivers in the GCR group. An orig-

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inator may also send a GCR MU-BAR Trigger frame with the AID12 fields set to 12 LSBs of the AIDs of HE STAs that transmit the BlockAck frames and the Block Ack Starting Sequence Control subfield set to the Sequence Number field of the earliest A-MSDU of the GCR stream that has not been acknowledged by all group members and has not expired due to lifetime limits, in order to minimize buffering latency at receivers in the GCR group.

NOTE 2—This is because an originator might transmit Management frames, QoS Data frames with a group address in the Address 1 field (including different GCR streams), and non-QoS Data frames intermingled. Since these are transmitted using a single sequence counter, missing frames or frames sent to group addresses absent from a receiving STA's dot11GroupAddresses table complicate receiver processing for GCR streams with a GCR block ack retransmission policy since the cause of a hole in a receiver's block ack bitmap is ambiguous: it is due either to an MPDU being lost from the GCR stream or to transmissions of MPDUs not related to the GCR service using the same sequence number counter.

Change the last paragraph as follows:

If the beginning of such reception does not occur during the first slot time following a SIFS, then the originator may perform error recovery by retransmitting a BlockAckReq frame or a GCR MU-BAR Trigger frame PIFS after the previous BlockAckReq frame or a GCR MU-BAR Trigger frame when both of the following conditions are met:

— The carrier sense mechanism (see 10.3.2.1 (CS mechanism)) indicates that the medium is idle at the TxPIFS slot boundary (defined in 10.3.7 (DCF timing relations)) after the expected start of a BlockAck frame, and

— The remaining duration of the GCR TXOP is longer than the total time required to retransmit the GCR BlockAckReq frame or a GCR MU-BAR Trigger frame plus one slot time.

NOTE 3—If an originator fails to receive a BlockAck frame in response to a BlockAckReq frame and there is insufficient time to transmit a recovery frame, the AP retransmits the BlockAckReq frame in a new TXOP.

10.28 Reverse direction protocol

10.28.1 General

Change the 2nd paragraph as follows:

An HT STA indicates support of the RD feature as an RD responder using the RD Responder subfield of the HT Extended Capabilities field of the HT Capabilities element. A STA shall set the RD Responder subfield to 1 in frames that it transmits containing the HT Capabilities element if dot11RDResponderOptionImplemented is true. Otherwise, the STA shall set the RD Responder subfield to 0. In ~~an~~ a non-HE HT STA the RDG/More PPDU subfield and the AC Constraint subfield are present in the HTC field. In an HE STA the RDG/More PPDU subfield and the AC Constraint subfield are present in the CAS Control field.

10.28.2 Reverse direction (RD) exchange sequence

Change NOTE 2 as follows:

NOTE 2—If the RD responder is a VHT AP, the RD response burst can contain VHT MU PPDUs that might have TXVECTOR parameter NUM_USERS > 1. If the RD responder is an HE AP, the RD response burst can contain HE MU PPDUs that might have TXVECTOR parameter NUM_USERS > 1.

10.28.3 Rules for RD initiator

Change the 3rd and subsequent 3 paragraphs as follows:

Transmission of a +HTC or DMG frame by an RD initiator with the RDG/More PPDU subfield equal to 1 (either transmitted as a non-A-MPDU frame, as an S-MPDU, or within an A-MPDU) indicates that the dura-

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tion indicated by the Duration/ID field is available for the RD response burst and RD initiator final PPDU (if present). Transmission of an MPDU by an HE RD initiator that contains a CAS Control field with the RDG/More PPDU subfield equal to 1 indicates that the duration indicated by the Duration/ID field is available for the RD resposnse burst and RD initiator final PPDU (if present).

An RD initiator that sets the RDG/More PPDU field to 1 in a +HTC or DMG frame transmitted during a TXOP shall set the AC Constraint subfield to 1 in that frame if the TXOP was gained through the EDCA channel access mechanism and shall otherwise set it to 0. An RD initiator that sets the RDG/More PPDU field to 1 in a DMG frame transmitted during an SP can set the AC Constraint subfield to 1 to limit the Data frames transmitted by the RD responder. An HE STA RD initiator that sets the RDG/More PPDU field to 1 in a CAS Control field in a frame transmitted during a TXOP may set the AC Constraint subfield in the CAS Control field to 1.

An RD initiator shall not transmit a +HTC or DMG frame with the RDG/More PPDU subfield set to 1 that requires a response MPDU that is not one of the following frames:

— Ack
— Compressed BlockAck
— Multi-STA BlockAck

Subject to TXOP or SP constraints, after transmitting an RDG PPDU, an RD initiator may transmit its next PPDU as follows:

a) *Normal continuation:* The RD initiator may transmit its next PPDU a minimum of a SIFS after receiving a response PPDU that meets one of the following conditions:
   1) Contains one or more received +HTC or DMG frames with the RDG/More PPDU subfield equal to 0
   2) In an HT STA, contains one or more received frames that are capable of carrying the HT Control field but did not contain an HT Control field
   3) Contains a received frame that requires an immediate response
   4) In a DMG STA, none of the correctly received frames in the PPDU carry the QoS Control field
b) *Error recovery:* The RD initiator may transmit its next PPDU when the CS mechanism (see 10.3.2.1 (CS mechanism)) indicates that the medium is idle at the TxPIFS slot boundary (see Figure 10-26 (EDCA mechanism timing relationships)) (this transmission is a continuation of the current TXOP or SP).

NOTE 4—Error recovery of the RDG mechanism is the responsibility of the RD initiator.

NOTE 5—After transmitting a PPDU containing an RDG, if the response is corrupted so that the state of the RDG/More PPDU subfield is unknown, the RD initiator of the RD exchange is not allowed to transmit after a SIFS. Transmission can occur a PIFS after deassertion of CS.

NOTE 6—Control response frames generated by HE STAs are assumed to not be capable of carrying the HT Control field.

10.28.4 Rules for RD responder

Change the 2nd paragraph as follows:

The recipient of an RDG may decline the RDG by

— Not transmitting any frames following the RDG PPDU when no response is otherwise required, or
— Transmitting a control response frame with the RDG/More PPDU subfield set to 0, or
— Transmitting a control response frame that contains no HT Control field

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— Transmitting a control response frame aggregated with other MPDUs with the RDG/More PPDU subfield set to 0

Change the 5th, 6th and 7th paragraph as follows:

An RD responder shall not transmit an MPDU (either individually or aggregated within an A-MPDU) that is not one of the following frames:

— Ack
— Compressed BlockAck
— Compressed BlockAckReq
— Extended Compressed BlockAck
— Extended Compressed BlockAckReq
— Multi-STA BlockAck
— QoS Ddata
— QoS Null
— Management

~~If the AC Constraint subfield is equal to 1, the RD responder shall transmit Data frames of only the same AC as the last frame received from the RD initiator.~~ If the AC Constraint subfield is equal to 1 in last frame received from an RD initiator:

— A non-HE RD responder shall transmit Data frames of only the same AC as the last frame received from the RD initiator
— An HE RD responder may transmit A-MPDU with or multi-TID A-MPDU with MPDUs from one or more ACs that have a priority that is equal to or higher than the lowest priority AC of the MPDU(s) carried in the last PPDU received from the RD initiator (see 10.13 (A-MPDU operation) and when the RD initiator is an HE STA subject to the additional rules defined in 27.10.4(A-MPDU with multiple TID).

For a BlockAckReq or BlockAck frame, the AC is determined by examining the TID field. For a Management frame, the AC is AC_VO. The RD initiator shall not transmit a +HTC or DMG MPDU with the RDG/More PPDU subfield set to 1 from which the AC cannot be determined. If the AC Constraint subfield is equal to 0, the RD responder may transmit Data frames of any TID.

During an RD response burst any PPDU transmitted by an RD responder shall contain at least one MPDU with an Address 1 field that matches the MAC address of the RD initiator, and the inclusion of traffic to STAs other than the RD initiator in a VHT MU PPDU or HE MU PPDU shall not increase the duration of the ~~VHT MU~~ PPDU beyond that required to transport the traffic to the RD initiator. The RD responder shall not transmit any frame causing a response after SIFS with an Address 1 field that does not match the MAC address of the RD initiator. The RD responder shall not transmit any PPDUs with a CH_BANDWIDTH that is wider than the CH_BANDWIDTH of the PPDU containing the frame(s) that delivered the RD grant.

10.43 Target wake time (TWT)

10.43.1 TWT overview

Change the 2nd paragraph as follows:

A TWT requesting STA communicates wake scheduling information to its TWT responding STA and the TWT responding STA devises a schedule and delivers TWT values to the TWT requesting STA when a TWT agreement has been established between them. When explicit TWT is employed, a TWT requesting

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STA wakes and performs a frame exchange and receives the next TWT information in a response from the TWT responding STA as described in 10.43.2.2 (Explicit TWT operation). When implicit TWT is used, the TWT requesting STA calculates the Next TWT by adding a fixed value to the current TWT value as described in 10.43.3 (Implicit TWT operation).

Insert new paragraphs and table as follows after the 9th paragraph:

The result of an exchange of TWT Setup frames between a TWT requesting STA and a TWT responding STA is defined in Table 10-19a. In general, the meaning of Request TWT is that the transmitting STA does not provide a set of TWT parameters for a TWT agreement, leaving the choice of parameters to the responding STA, Suggest TWT indicates that the transmitting STA offers a set of preferred TWT parameters for a TWT agreement but might accept alternative TWT parameters that the responding STA indicates and Demand TWT indicates that the transmitting STA will currently accept only the indicated TWT parameters for a TWT agreement. Reject TWT transmitted by a responding STA as part of a negotiation for a new TWT agreement is used to indicate that the negotiation has ended in failure to create a new TWT agreement. When transmitted by a responding STA, Accept TWT indicates that the responding STA has initiated a TWT agreement with the given parameters, Alternate TWT indicates a counter-offer of TWT parameters without the creation of a TWT agreement and Dictate TWT indicates that no TWT agreement is created, but one is likely to be created using the indicated TWT parameters if the requesting STA transmits a new TWT setup request with those parameters.

Table 10-19a—TWT setup exchange command interpretation

Initiating frame: TWT Setup Command field value within a TWT Setup frame transmitted from a first STA to a second STA	Response frame: TWT Setup Command field value within a TWT Setup frame transmitted from the second STA to the first STA	TWT condition after the completion of the exchange
Request TWT or Suggest TWT or Demand TWT	No frame transmitted	No new individual TWT agreement exists with the TWT flow identifier corresponding to the TWT flow identifier in the initiating frame. No new individual TWT agreement exists.
Demand TWT	Accept TWT	An individual TWT agreement exists that uses the TWT parameters identified in the initiating frame. The TWT parameters in the response frame match the TWT parameters of the initiating frame.
Suggest TWT or Request TWT	Accept TWT	An individual TWT agreement exists and that uses the TWT parameters identified in the response frame.
Demand TWT	Alternate TWT or Dictate TWT	No individual TWT agreement exists with the associated TWT flow identifier. The responder is offering an alternative set of parameters vs. those indicated in the initiating frame. The requesting STA can send a new request with any set of TWT parameters and the responder might create an individual TWT agreement using those parameters.

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Table 10-19a—TWT setup exchange command interpretation

Suggest TWT	Alternate TWT	No individual TWT agreement exists with the associated TWT flow identifier. The responder is offering an alternative set of parameters to those indicated in the initiating frame, as a means of negotiating TWT parameters with the requester. The requesting STA can send a new request with any set of TWT parameters and the responder might create an individual TWT agreement using those parameters.
Suggest TWT	Dictate TWT	No individual TWT agreement exists with the associated TWT flow identifier. The responder offers an alternative set of parameters vs. those indicated in the TWT request. By selecting "Dictate TWT", the responder indicates that it is not willing to accept any other TWT parameters for the requesting STA at this time. The requesting STA can send a new request, but will only receive an Accept TWT if it uses the dictated TWT parameters.
Request TWT or Suggest TWT or Demand TWT	Reject TWT	No individual TWT agreement exists with the associated TWT flow identifier. The responding STA will not create any new individual TWT agreement with the requester at this time.
NOTE—Request frame settings not listed in the table are not allowed.		

A TWT requesting STA and a TWT responding STA shall set the Broadcast subfield to 0 and the Wake TBTT Negotiation subfield to 0 in the TWT element of transmitted TWT Setup request frames.

Additional TWT setup frame exchanges between HE STAs are defined in 27.7 (TWT operation).

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11. MLME

11.1 Synchronization

11.1.3 Maintaining synchronization

11.1.3.8 Multiple BSSID procedure

Change the 1st paragraph as follows:

Implementation of the Multiple BSSID capability is optional for a WNM STA and for a DMG STA. A STA that implements the Multiple BSSID capability has dot11MultiBSSIDImplemented equal to true. When dot11MultiBSSIDImplemented is true, dot11WirelessManagementImplemented shall be equal to true except for a DMG STA and an HE STA, in which case it may be equal to false. A STA in which dot11MultiBSSIDActivated is true is defined as a STA that supports the Multiple BSSID capability. The STA shall set to 1 the Multiple BSSID field of the Extended Capabilities elements that it transmits.

Insert the following at the end of the subclause:

The BSSID of an AP belonging to a multiple BSSID set is the transmitted BSSID if the AP includes the Multiple BSSID element in the Beacon and Probe Response frames it transmits. In a multiple BSSID set, there shall not be more than one AP corresponding to the transmitted BSSID. The BSSID of an AP belonging to a multiple BSSID set is a nontransmitted BSSID if the AP's BSSID can be derived from Multiple BSSID element present in the Beacon frame or Probe Response frame transmitted by the AP whose BSSID is the transmitted BSSID.

An HE AP belonging to a multiple BSSID set shall set the MaxBSSID Indicator field and Tx BSSID Indicator field in the HE Operation element as defined in 9.4.2.238 (HE Operation element).

An HE STA that supports receiving control frames directed to STAs from at least two different BSSs of a multiple BSSID set (i.e., has the Rx Control Frame To MultiBSS subfield set to 1 in the HE Capabilities element it transmits) and is associated with an HE AP whose MaxBSSID Indicator field is set to n and whose Tx BSSID Indicator is set to 0 shall decode the Beacon frame with a Multiple BSSID element whose $48 - n$ MSBs of the BSSID are same as the $48 - n$ MSBs of BSSID of the AP with which the STA is associated in order to identify the transmitted BSSID.

11.1.4 Acquiring synchronization, scanning

11.1.4.3 Active scanning

11.1.4.3.4 Criteria for sending a response

Change the 2nd paragraph, inserting a new item in the list following item 3) as follows:

A FILS STA shall not respond to a Probe Request frame if any of the following criteria is met for a FILS Request Parameters element contained in the Probe Request frame:

3a) If the FILS Criteria field is present in the FILS Requests Parameters element and the PHY Support Criterion of the FILS Criteria field of the FILS Request Parameters element is 3 and the responding STA is not HE capable.

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11.2 Power management

11.2.3 Power management in a non-DMG infrastructure network

11.2.3.6 AP operation during the CP

Change item g) in the 2nd paragraph as follows:

g) When the AP receives a PS-Poll frame from a STA that is in PS mode, it shall forward to the STA a single buffered BU. The AP shall respond after a SIFS either with a Data or Management frame, or with an Ack frame; in which case the corresponding Data or Management frame is delayed. Until the transmission of this BU either has succeeded or is presumed failed (when maximum retries are exceeded), the AP shall acknowledge but ignore all PS-Poll frames from the same STA. This prevents a retried PS-Poll frame from being treated as a new request to deliver a buffered BU.

For a STA using U-APSD, the AP transmits one BU destined for the STA from any AC that is not delivery-enabled in response to PS-Poll frame from the STA. The AP should transmit the BU from the highest priority AC that is not delivery-enabled and that has a buffered BU. When all ACs associated with the STA are delivery-enabled, the AP transmits one BU from the highest priority AC that has a BU.

For a STA in PS mode and not using U-APSD, the AP shall set the More Data subfield of the response Data or Management frame to 1 to indicate the presence of further buffered BUs (not including the BU currently being transmitted) for the polling STA. For a STA using U-APSD, the AP shall set the More Data subfield to 1 to indicate the presence of further buffered BUs (not including the BU currently being transmitted) that do not use delivery-enabled ACs. When all ACs associated with the STA are delivery-enabled, the AP shall set the More Data subfield to 1 to indicate the presence of further buffered BUs (not including the BU currently being transmitted) using delivery-enabled ACs.

If there are buffered BUs to transmit to the STA, the AP may set the More Data bit in a QoS +CFAck frame to 1 in response to a QoS Data frame to indicate that it has one or more pending BUs buffered for the PS STA identified by the RA in the QoS +CF-Ack frame. An AP may also set the More Data bit in an Ack frame to 1 in response to a QoS Data frame to indicate that it has one or more pending BUs buffered for the PS STA identified by the RA in the Ack frame, if that PS STA has set the More Data Ack subfield in the QoS Capability element to 1. <u>An HE AP may also set the More Data bit in a BlockAck or Multi-STA BlockAck frame to 1 to indicate that it has one or more pending BUs buffered for the HE PS STA identified by the RA in the BlockAck or Multi-STA Blockack frame, if that HE PS STA has set the More Data Ack subfield in the QoS Capability element to 1. An HE AP indicates support of sending Ack, BlockAck, or Multi-STA BlockAck frames with a nonzero More Data subfield by setting the More Data Ack subfield to 1 in the QoS Info field of frames it transmits.</u>

Unless indicated above, the AP shall set the More Data bit to 0.

11.2.3.8 Receive operation for STAs in PS mode during the CP

Change item e) in the 2nd paragraph as follows:

The following rules describe operation of a STA in PS mode during the CP:

e) When dot11FMSActivated is false and ReceiveDTIMs is true, the STA shall wake up early enough to be able to receive either every non-STBC DTIM or every STBC DTIM sent by the AP of the BSS. When dot11FMSActivated is true and ReceiveDTIMs is true and the STA has been granted by the AP an alternate delivery interval for a multicast stream, the STA shall wake up before the non-STBC

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DTIM or STBC DTIM having Current Count of FMS Counter field set to 0 for that particular FMS stream.

A STA that stays awake to receive group addressed BUs shall elect to receive all group addressed non-STBC transmissions or all group addressed STBC transmissions and remain awake until the More Data subfield of the appropriate type (non-STBC or STBC) of group addressed BUs indicates there are no further buffered group addressed BUs of that type, or until a TIM is received indicating there are no more buffered group addressed BUs of that type, or until an FMS Descriptor element is received indicating that there are no further buffered group addressed BUs for which the STA has previously received an FMS Response element in a frame that has a value in Address 1 that matches its MAC address or that has an Address 1 value that is a group address corresponding to a group of which it is a member and that was transmitted by the AP with which it is associated and which had an Element Status value in the FMS Status subelement of "Accept". If a STA receives a QoS +CFAck frame from its AP with the More Data bit equal to 1, then the STA shall operate ~~exactly~~ as if it received a TIM with its AID bit equal to 1. If a STA has set the More Data Ack subfield in QoS Capability element to 1, then if it receives an Ack frame from its AP with the More Data bit equal to 1, the STA shall operate ~~exactly~~ as if it received a TIM with its AID bit equal to 1. If an HE STA has set the More Data Ack subfield in the QoS Capability element to 1, then if it receives a BlockAck or Multi-STA BlockAck frame from its AP with the More Data bit equal to 1, the STA shall operate as if it received a TIM with its AID bit equal to 1. For example, a STA that is using the PS-Poll delivery method shall issue a PS-Poll frame to retrieve a buffered BU. See also 10.3.6 (Group addressed MPDU transfer procedure).

11.2.3.17 TIM Broadcast

Change the 11th paragraph as follows:

The AP shall increase the value (modulo 256) of the Check Beacon field in the next transmitted TIM frame(s) when a critical update occurs to any of the elements inside the Beacon frame. The following events shall classify as a critical update:

a) Inclusion of a Channel Switch Announcement element
b) Inclusion of an Extended Channel Switch Announcement element
c) Modification of the EDCA parameters element
d) Inclusion of a Quiet element
e) Modification of the DSSS Parameter Set
f) Modification of the CF Parameter Set element
g) Modification of the HT Operation element
h) Inclusion of a Wide Bandwidth Channel Switch element
i) Inclusion of a Channel Switch Wrapper element
j) Inclusion of an Operating Mode Notification element
k) Inclusion of a Quiet Channel element
l) Modification of the VHT Operation element
m) Modification of the HE Operation element
n) Insertion of a Broadcast TWT element
o) Inclusion of the BSS Color Change Announcement element

NOTE—Modification of an element means that at least one value of a field in the element is changed. Inclusion of an element means that the element is included to a Beacon frame. The Insertion of an element means that the element was not present in the previous Beacon frame and is present in the current Beacon frame.

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11.3 STA authentication and association

11.3.5 Association, reassociation, and disassociation

11.3.5.3 AP or PCP association receipt procedures

Insert the following list item after item h, adjusting the subsequent item numbering accordingly:

i) The SME shall refuse an association request from an HE STA that does not support all of the <HE-MCS, NSS> tuples indicated by the Basic HE-MCS And NSS Set field of the HE Operation parameter in the MLME-START.request primitive.

11.3.5.5 AP or PCP reassociation receipt procedures

Insert the following list item after item h, adjusting the subsequent item numbering accordingly:

i) The SME shall refuse a reassociation request from an HE STA that does not support all of the <HE-MCS, NSS> tuples indicated by the Basic HE-MCS And NSS Set field of the HE Operation parameter in the MLME-START.request primitive.

11.3.8 Neighbor report information upon rejection with suggested BSS transition

Insert the following at the end of the subclause:

An HE STA that has received from an HE AP an Authentication or (Re)Association Response frame that has the Status Code field set to REJECTED_WITH_SUGGESTED_BSS_TRANSITION and that includes one or more Neighbor Report elements for BSSs that are part of the ESS of the HE AP shall, if it re-attempts to associate with the ESS, select an AP from (one of) the Neighbor Report element(s).

11.23 Tunneled direct-link setup

11.23.1 General

Change as follows:

The VHT Operation element shall be present in a TDLS Setup Confirm frame when both STAs are VHT capable and the TDLS direct link is not established in the 2.4 GHz band. When the TDLS Setup Confirm frame includes a VHT Operation element, the Basic VHT-MCS And NSS Set field is reserved.

The HE Operation element shall be present in a TDLS Setup Confirm frame when both STAs are HE capable.

11.24 Wireless network management procedures

11.24.2 Event request and report procedures

Change the 1st paragraph and insert a new paragraph as follows:

The Event Request and Event Report frames enable network real-time diagnostics. A STA whose dot11EventsActivated is true shall support event requests and reports and shall set to 1 the Event field of the Extended Capabilities elements that it transmits. If dot11EventsActivated is true and the Event Type is not BSS Color Collision, a STA shall log all Transition, RSNA, peer-to-peer, and WNM log events, including the corresponding TSF, UTC Offset and Event Time Error.

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A STA whose dot11AutonomousBSSColorCollisionReportingImplemented is true shall set the Event field of the Extended Capabilities elements that it transmits to 1.

Insert a new subclause at the end of 11.24.2:

11.24.2.7 BSS Color Collision event

The BSS color collision event report enables a non-AP HE STA to inform its associated AP whether a BSS color collision has occurred. The report carries information about the BSS color used by OBSSs that the reporting STA is able to detect.

11.24.6 Fine timing measurement procedure

11.24.6.4 Measurement exchange

Change the 10th paragraph as follows:

For the Fine Timing Measurement frames transmitted during the FTM session:

- The responding STA shall not use a bandwidth wider than that indicated by the STA in the initial Fine Timing Measurement frame.
- The responding STA shall not use an HE format if the STA indicated VHT or HT-mixed or non-HT format in the initial Fine Timing Measurement frame.
- The responding STA shall not use a VHT format if the STA indicated HT-mixed or non-HT format in the initial Fine Timing Measurement frame.
- The responding STA shall not use an HT format if the STA indicated non-HT format in the initial Fine Timing Measurement frame.

11.24.7 BSS transition management for network load balancing

11.24.7.1 BSS transition capability

Change the 3rd paragraph as follows:

Implementation of BSS transition management is optional for a WNM STA that is not a non-AP HE STA. A STA that implements BSS transition management has dot11BSSTransitionImplemented equal to true. When dot11BSSTransitionImplemented is true, dot11WirelessManagementImplemented shall be true. A STAwhose dot11BSSTransitionActivated is true shall support BSS transition management and shall set to 1 the Transition field of the Extended Capabilities elements that it transmits. A non-AP HE STA shall have dot11BSSTransitionImplemented and dot11BSSTransitionActivated equal to true.

11.24.7.4 BSS transition management response

Change the 2nd paragraph as follows:

The STA's SME may include the result of its BSS transition decision in the Target BSSID field and BTM Status Code field in the MLME-BTM.response primitive. A BTM Status Code field set to a value of 0 (i.e., Accept) indicates the STA will transition from the current BSS. The non-HE STA's SME receiving an MLMEBTM.indication primitive may issue an MLME-BTM.response primitive with a valid status code not equal to a value of 0 (i.e., Accept) indicating rejection if it is unable to comply with this BSS transition management request.

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The HE STA's SME receiving an MLME-BTM.indication primitive shall issue an MLME-BTM.response primitive with a valid status code not equal to a value of 0 (i.e., Accept) indicating rejection if it is unable to comply with this BSS transition management request.

Insert a new subclause at the end of 11.24.7 as follows:

11.24.7.5 Planned ESS

The AP can indicate that it is in a planned ESS to assist associated STAs' roaming. If it does, it indicates whether it is at the physical edge of the ESS, and can provide a recommendation on the RSSI level to consider for BSS transition.

The Planned ESS subfield in the ESS Information field indicates whether the AP is part of an ESS which is planned with several BSSs in overlapping configuration, whereby an associated STA may adjust its BSS transition algorithms accordingly.

NOTE 1—In a planned ESS the non-AP STA could use the Recommended BSS Transition Threshold Within The ESS subfield to modify when it starts scanning for a new BSS. However, how the non-AP STA adjusts its BSS transition algorithms is implementation specific and beyond the scope of this standard.

The Edge Of ESS subfield in the ESS Information field indicates to the non-AP STA that it is associated with a BSS at the edge of an ESS (e.g., exit of a building).

NOTE 2—The non-AP STA can prepare for more aggressive roaming or the device the non-AP STA is in can prepare for switching to a different system. However, how the non-AP STA uses the edge of an ESS information is implementation specific and beyond the scope of this standard.

The Recommended BSS Transition Threshold Within ESS subfield indicates to the non-AP STA the Beacon RSSI below which it should initiate a BSS transition. The value of the Edge Of ESS subfield and the Recommended BSS Transition Threshold Within ESS subfield may be changed by the AP STA if conditions in the ESS change. An HE AP should not change the value of the Planned ESS subfield within the lifetime of the BSS.

11.47 Fast Initial Link Setup (FILS) procedures

11.47.2 FILS Discovery frame generation and usage

11.47.2.1 FILS Discovery frame transmission

Change the 3rd paragraph as follows:

If an AP transmits a FILS Discovery frame as a non-HT duplicate PPDU in an 80+80 MHz channel bandwidth, the Channel Center Frequency Segment 1 field shall be present in the FILS Discovery frame and shall be set to the channel center frequency of the frequency segment 1 for an 80+80 MHz VHT or HE operating channel.

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17. Orthogonal frequency division multiplexing (OFDM) PHY specification

17.3 OFDM PHY

17.3.9 PHY transmit specifications

Insert a new subclause at the end of 17.3.9 as follows:

17.3.9.10 Pre-correction accuracy requirements

A STA that transmits a non-HT or non-HT duplicate PPDU where the TXVECTOR parameter TRIGGER_RESPONDING is true shall pre-compensate for carrier frequency offset (CFO) error with respect to the PPDU that carries the soliciting MU-RTS Trigger frame and symbol clock error. After compensation, the absolute value of residual CFO error with respect to the PPDU carrying the soliciting MU-RTS Trigger frame shall not exceed 2 kHz when measured at the 10% point of complementary cumulative distribution function (CCDF) of CFO errors in AWGN at a received power of −60 dBm in the primary 20 MHz. The residual CFO error measurement shall be made on the non-HT PPDU or non-HT duplicate PPDU following the L-STF field. The symbol clock error shall be pre-compensated by the same ppm amount as CFO error.

A STA that transmits a non-HT or non-HT duplicate PPDU where the TXVECTOR parameter TRIGGER_RESPONDING is true shall have timing accuracy of ±0.4 μs relative to the ending time of the PPDU carrying the MU-RTS Trigger frame not accounting for the impact of propagation delay. The STA is not expected to compensate for round trip delay.

NOTE—The timing requirement for transmitting an non-HT or non-HT duplicate PPDU when the TXVECTOR parameter TRIGGER_RESPONDING is true is the same as the timing requirement for transmitting an HE TB PPDU.

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18. Extended Rate PHY (ERP) specification

18.2 PHY-specific service parameter list

Insert two new last rows into Table 18-1 as follows:

Table 18-1—TXVECTOR parameters

Parameter	Value
CH_BANDWIDTH_IN_NON_HT	If present, CBW20 or CBW40
DYN_BANDWIDTH_IN_NON_HT	If present, Static or Dynamic

Insert two new last rows into Table 18-3 as follows:

Table 18-3—RXVECTOR parameters

Parameter	Value
CH_BANDWIDTH_IN_NON_HT	If present, CBW20 or CBW40
DYN_BANDWIDTH_IN_NON_HT	If present, Static or Dynamic

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Insert new Clauses 27 and 28 following Clause 26 as follows:

27. High Efficiency (HE) MAC specification

27.1 Introduction

An HE STA supports the MAC and MLME functions defined in Clause 27 in addition to the MAC functions defined in Clause 10 and the MLME functions defined in Clause 11, except when the functions in Clause 27 supersede the functions in Clause 10 or Clause 11.

27.2 HE channel access

27.2.1 TXOP duration-based RTS/CTS

In dense environments, management by an AP of RTS usage can help mitigate interference since the AP might have a better view of the interference situation. To improve spectrum utilization, RTS usage should be TXOP duration-based, rather than PSDU length-based.

An HE AP may set the TXOP Duration RTS Threshold subfield of HE Operation elements it transmits to a value less than 1023 to require the use of dot11TXOPDurationRTSThreshold by its associated STAs for enabling RTS/CTS exchanges. The AP may set the TXOP Duration RTS Threshold field to 1023 to not require the use of dot11TXOPDurationRTSThreshold by its associated STAs for enabling RTS/CTS exchanges.

An HE non-AP STA shall set its dot11TXOPDurationRTSThreshold to the TXOP Duration RTS Threshold subfield in the most recently received HE Operation element sent by the AP to which the STA is associated. The dot11TXOPDurationRTSThreshold is not present at a non-HE non-AP STA.

TXOP duration based RTS operation is disabled at a STA when dot11TXOPDurationRTSThreshold is either not present or is equal to 1023. TXOP duration based RTS is enabled at a STA when dot11TXOPDurationRTSThreshold is less than 1023.

A non-AP STA shall use an RTS/CTS exchange to obtain the TXOP when all the following conditions are met:

— The STA intends to transmit individually addressed frames to the HE AP or to a TDLS peer STA
— The TXOP duration is greater than or equal to 32 μs × dot11TXOPDurationRTSThreshold
— dot11TXOPDurationRTSThreshold is not 1023

27.2.2 Intra-BSS and inter-BSS frame determination

A STA that obtains at least the RXVECTOR for a PPDU shall classify the PPDU as an inter-BSS frame if at least one of the following conditions is true:

— The RXVECTOR parameter BSS_COLOR is not 0 and is not the BSS color of the BSS of which the STA is a member.
— The PPDU is an HE PPDU with the RXVECTOR parameter BSS_COLOR not equal to 0 and the STA is an HE STA associated with a non-HE AP.
— The PPDU is a VHT PPDU with RXVECTOR parameter PARTIAL_AID not equal to the BSSID[39:47] of the BSS or the BSSID of any BSS that is a member of the same multiple BSSID set as the BSS of which the STA is a member and the RXVECTOR parameter GROUP_ID is 0.

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- The PPDU is a VHT PPDU with RXVECTOR parameter PARTIAL_AID[5:8] not equal to the partial BSS color announced by the BSS of which the STA whose dot11PartialBSSColorImplemented is equal to true is a member and RXVECTOR parameter GROUP_ID equal to 63 when the Partial BSS Color field in the most recent HE Operation element is 1.
- The PPDU is either a VHT MU PPDU or an HE MU PPDU with the RXVECTOR parameter UL_FLAG equal to 0 and the STA is an AP.
- The PPDU carries a frame that has a BSSID field, the value of which is not the BSSID of the BSS or any BSS that is a member of the same multiple BSSID set as the BSS of which the STA is a member..
- The PPDU carries a frame that does not have a BSSID field but has both an RA field and TA field, neither value of which is equal to the BSSID of the BSS or the BSSID of any BSS that is a member of the same multiple BSSID set as the BSS of which the STA is a member. The Individual/Group bit in the TA field value is forced to 0 prior to comparison.

Otherwise, a STA that obtains at least the RXVECTOR for a PPDU shall classify the PPDU as an intra-BSS frame if at least one of the following conditions is true:

- The RXVECTOR parameter BSS_COLOR of the PPDU carrying the frame is 0 or the BSS color of the BSS of which the STA is a member.
- The PPDU is a VHT PPDU with RXVECTOR parameter PARTIAL_AID equal to the BSSID[39:47] of the BSS or of any BSS that is a member of the same multiple BSSID set as the BSS of which the STA is a member, and the RXVECTOR parameter GROUP_ID equal to 0
- The PPDU is a VHT PPDU with RXVECTOR parameter PARTIAL_AID[5:8] equal to the partial BSS color of the BSS of which the STA whose dot11PartialBSSColorImplemented is equal to true is a member, the RXVECTOR parameter GROUP_ID is equal to 63 and the Partial BSS Color field in the most recent HE Operation element is 1.
- The PPDU carries a frame that has an RA, TA or BSSID field value that is equal to the BSSID of the BSS or the BSSID of any BSS that is a member of the same multiple BSSID set as the BSS of which the STA is a member. The Individual/Group bit in the TA field value is forced to the value 0 prior to the comparison.)
- The PPDU carries a Control frame that does not have a TA field and that has an RA field value that matches the saved TXOP holder address of the BSS or any BSS that is a member of the same multiple BSSID set as the BSS of which the STA is a member.

NOTE—See 10.20 for the definition of PARTIAL_AID[5:8] and BSSID[39:47].

Otherwise, the PPDU cannot be determined as an intra-BSS or inter-BSS frame.

If the received frame satisfies both intra-BSS and inter-BSS conditions, the decision made by using the MAC address takes precedence over the decision made by using the RXVECTOR parameter BSS_COLOR.

If the received frame does not satisfy any of the intra-BSS and inter-BSS conditions, then the frame is neither an intra-BSS frame nor an inter-BSS frame.

A PPDU carrying at least one inter-BSS frame is an inter-BSS PPDU. A PPDU carrying at least one intra-BSS frame is an intra-BSS PPDU.

27.2.3 SRG and non-SRG frame determination

An HE STA that has received a Spatial Reuse Parameter Set element from its associated AP with a value of 1 in the SRG Information Present subfield shall use information provided in the Spatial Reuse Parameter Set element to identify BSSs that are members of the STA's SRG to determine whether or not a received inter-BSS PPDU is an SRG PPDU.

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A received HE PPDU that is an inter-BSS PPDU is an SRG PPDU if the bit in the SRG BSS Color Bitmap field which corresponds to the numerical value of the BSS_COLOR parameter of the RXVECTOR is set to 1. A received VHT PPDU that is an inter-BSS PPDU is an SRG PPDU if the GROUP_ID parameter of the RXVECTOR has a value of 0 and the bit in the SRG Partial BSSID Bitmap field which corresponds to the numerical value of PARTIAL_AID[0:5] of the RXVECTOR is set to 1.

A received PPDU that is an inter-BSS PPDU is an SRG PPDU if BSSID information from an MPDU of the PPDU is correctly received and the bit in the SRG Partial BSSID Bitmap field which corresponds to the numerical value of BSSID[39:44] is set to 1.

Otherwise, the PPDU is not determined to be an SRG PPDU. An HE STA that has not received a Spatial Reuse Parameter Set element from its associated AP with a value of 1 in the SRG Information Present subfield shall not classify any received PPDUs as an SRG PPDU.

27.2.4 Updating two NAVs

A non-AP HE STA shall maintain and an HE AP may maintain two NAVs, one referred to as intra-BSS NAV and the other as basic NAV. Intra-BSS NAV is used to store NAV value, if needed, from a PPDU identified as intra-BSS. Basic NAV is used to store NAV value, if needed, from a PPDU classified as inter-BSS or from a PPDU that cannot be classified as intra-BSS or inter-BSS. The mechanism by which a PPDU is classified intra-BSS or inter-BSS is defined in 27.2.2 (Intra-BSS and inter-BSS frame determination).

Maintaining two NAVs is beneficial in dense deployment scenarios where a STA requires protection from frames transmitted by STAs within its BSS, i.e., intra-BSS, and avoid interference from frames transmitted by STAs in a neighboring BSS, i.e., inter-BSS. For example, in a TXOP initiated by the AP to which the STA is associated for an UL MU transmission, the intra-BSS NAV of the STA can be set by the AP to prevent the STA from contending for the channel. The basic NAV will not be updated by the AP so that the NAV set by an inter-BSS PPDU can be considered the UL MU CS mechanism described in 27.5.3.5 (UL MU CS mechanism).

The requirements in 10.3.2.1 (CS mechanism) apply to an HE STA maintaining two NAVs with the exception of the virtual CS indication of medium. For an HE STA maintaining two NAVs, if both the NAV timers are 0, the virtual CS indication is that the medium is idle; if one of the two NAV timers is nonzero, the virtual CS indication is that the medium is busy.

The procedure in 10.3.2.7 (CTS and DMG CTS procedure) applies to an HE STA maintaining two NAVs, and the NAV referred by the description in 10.3.2.7 is the basic NAV.

The duration information is indicated by a frame in a PSDU as follows:

— If there is a Duration field in the frame, then the duration information is indicated by the Duration field.

— If the frame is a PS-Poll, then the duration information is equal to the time, in microseconds, required to transmit one Ack frame plus one SIFS under the data rate selection rules. If the calculated duration information includes a fractional microsecond, that duration information is rounded up to the next higher integer.

A STA that is a TXOP holder shall update the intra-BSS NAV with the duration information indicated by the received frame in a PSDU if and only if all the following conditions are met:

— The frame is identified as intra-BSS according to the rule described in 27.2.2 (Intra-BSS and inter-BSS frame determination).

— The indicated duration is greater than the current intra-BSS NAV value.

— The RA of the received frame is not the STA's MAC address.

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A STA, that is not a TXOP holder, shall update the intra-BSS NAV with the duration information indicated by the received frame in a PSDU if and only if all the following conditions are met:

— The frame is identified as intra-BSS according to the rule described in 27.2.2 (Intra-BSS and inter-BSS frame determination).

— The indicated duration is greater than the current intra-BSS NAV value.

— The RA of the received frame is not the STA's MAC address or the PPDU carrying the frame does not solicit an immediate response from the STA STA or the received frame is a Trigger frame .

A STA shall update the basic NAV with the duration information indicated by the received frame in a PSDU if and only if all the following conditions are met:

— The frame is identified as inter-BSS or cannot be identified as intra-BSS or inter-BSS according to the rule described in 27.2.2 (Intra-BSS and inter-BSS frame determination).

— The indicated duration is greater than the current basic NAV value.

— The RA of the received frame is not the STA's MAC address.

A STA that is a TXOP holder shall not update the intra-BSS NAV with the duration information indicated by the RXVECTOR parameter TXOP_DURATION.

A STA that is not a TXOP holder shall update the intra-BSS NAV with the duration information indicated by the RXVECTOR parameter TXOP_DURATION if and only if all the following conditions are met:

— The RXVECTOR parameter TXOP_DURATION is not UNSPECIFIED.

— The PPDU that carried information of the RXVECTOR parameter is identified as intra-BSS according to the rule described in 27.2.2 (Intra-BSS and inter-BSS frame determination).

— The STA does not receive a frame with the duration information indicated by a Duration field in the PSDU of the PPDU with the RXVECTOR parameter TXOP_DURATION.

— The duration information indicated by the RXVECTOR parameter TXOP_DURATION is greater than the current intra-BSS NAV of the STA.

A STA shall update the basic NAV with the duration information indicated by the RXVECTOR parameter TXOP_DURATION if and only if all the following conditions are met:

— The RXVECTOR parameter TXOP_DURATION is not UNSPECIFIED.

— The PPDU that carried information for the RXVECTOR parameter is identified as inter-BSS or cannot be identified as intra-BSS or inter-BSS according to the rule described in 27.2.2 (Intra-BSS and inter-BSS frame determination).

— The STA does not receive a frame with the duration information indicated by a Duration field in the PSDU of the PPDU with the RXVECTOR parameter TXOP_DURATION.

— The duration information indicated by the RXVECTOR parameter TXOP_DURATION is greater than the current basic NAV of the STA.

NOTE 1—If a PS-Poll frame is received carried in a received HE SU PPDU, HE ER SU PPDU, or HE MU PPDU, then the RXVECTOR parameter TXOP_DURATION does not indicate duration information (see 27.11.5 (TXOP_DURATION).

NOTE 2—Based on the setting rule, if a STA receives a frame with the duration information indicated by both a Duration field in the PSDU and the RXVECTOR parameter TXOP_DURATION, then the duration information indicated by the RXVECTOR parameter TXOP_DURATION is ignored.

NOTE 3—The additional rules of NAV consideration for a STA that is solicited for an immediate response are described in 10.3.2.7 (CTS and DMG CTS procedure), 10.3.2.9 (Acknowledgment procedure), and 27.5.3.5 (UL MU CS mechanism).

A PHY-CCARESET.request primitive shall be issued if one of the following condition is met:

— One NAV is reset, and the other NAV timer is 0.

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— Both NAVs are reset simultaneously.

The exact time of updating the NAVs uses the same rule as defined in 10.3.2.4 (Setting and resetting the NAV).

An HE STA that used information from an RTS or MU-RTS Trigger frame as the most recent basis to update its NAV setting is permitted to reset the NAV which is updated by the RTS or MU-RTS if no PHY-RXSTART.indication primitive is received from the PHY during a period with a duration of 2 × aSIFSTime + CTS_Time + aRxPHYStartDelay + 2 × aSlotTime starting when the MAC receives a PHY-RXEND.indication primitive corresponding to the detection of the RTS or MU-RTS Trigger frame.

27.2.5 MU-RTS/CTS procedure

27.2.5.1 General

The MU-RTS/CTS procedure allows an AP to initiate a TXOP and protect the TXOP frame exchanges. An HE AP may transmit an MU-RTS Trigger frame to solicit simultaneous CTS responses from one or more HE STAs.

Figure 27-1 (Example of MU-RTS/CTS/DL MU PPDU/Acknowledgement Response and NAV setting) shows an example of the exchange of MU-RTS and simultaneous CTS responses to protect the DL MU PPDU and the acknowledgement responses.

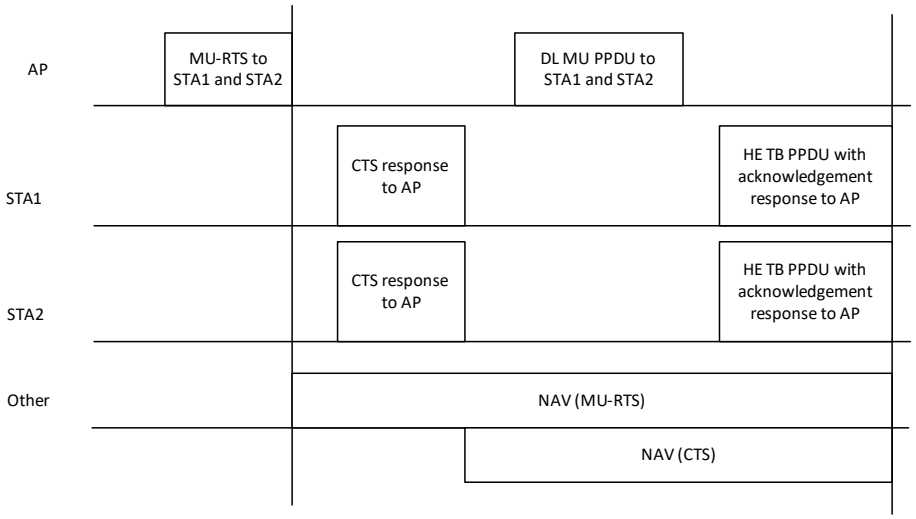


Figure 27-1—Example of MU-RTS/CTS/DL MU PPDU/Acknowledgement Response and NAV setting

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Figure 27-2 (Example of MU-RTS/CTS/Trigger/HE TB PPDU/Multi-STA BlockAck and NAV setting) shows an example of the exchange of MU-RTS and simultaneous CTS responses to protect the HE TB PPDU and Multi-STA BlockAck frame.

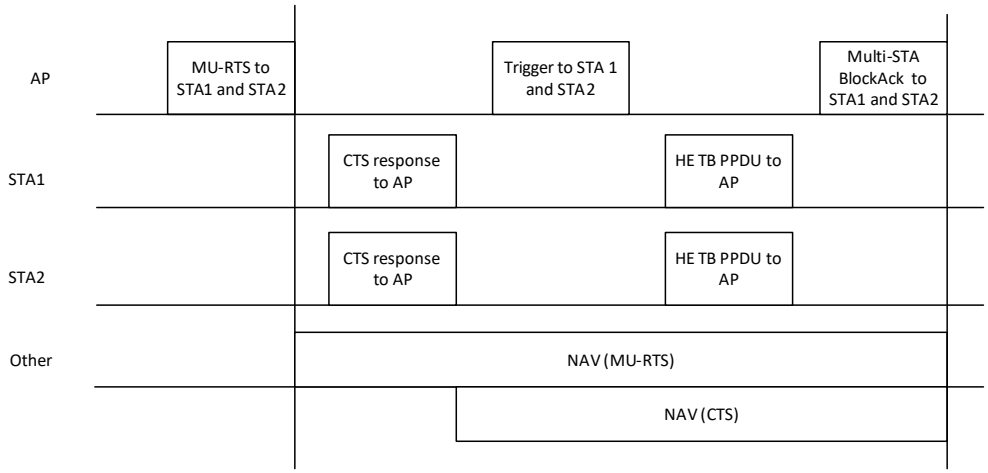


Figure 27-2—Example of MU-RTS/CTS/Trigger/HE TB PPDU/Multi-STA BlockAck and NAV setting

27.2.5.2 MU-RTS procedure

In each 20 MHz channel occupied by the PPDU that contains an MU-RTS Trigger frame, the transmitter of the MU-RTS Trigger frame shall request at least one STA to send a CTS frame response that occupies the 20 MHz channel. The transmitter of an MU-RTS Trigger frame shall not request a STA to send a CTS frame response in a 20 MHz channel that is not occupied by the PPDU that contains the MU-RTS Trigger frame.

After transmitting an MU-RTS Trigger frame, the STA shall wait for a CTSTimeout interval with a value of aSIFSTime + aSlotTime + aRxPHYStartDelay. This interval begins when the MAC receives a PHY-TXEND.confirm primitive. If a PHY-RXSTART.indication primitive does not occur during the CTSTimeout interval, the STA shall conclude that the transmission of the MU-RTS Trigger frame has failed, and this STA shall invoke its backoff procedure upon expiration of the CTSTimeout interval. If a PHY-RXSTART.indication primitive does occur during the CTSTimeout interval, the STA shall wait for the corresponding PHY-RXEND.indication primitive to determine whether the MU-RTS Trigger frame transmission was successful. The recognition of a valid CTS frame sent by any recipient of the MU-RTS Trigger frame, corresponding to this PHY-RXEND.indication primitive, shall be interpreted as the successful transmission of the MU-RTS Trigger frame, permitting the frame exchange sequence to continue. The recognition of anything else, including any other valid frame, shall be interpreted as failure of the MU-RTS Trigger frame transmission. In this instance, the STA may process the received frame and shall invoke its backoff procedure at the PHY-RXEND.indication primitive.

An MU-RTS Trigger frame shall not be carried in a VHT MU PPDU or an HE MU PPDU.

27.2.5.3 CTS response to MU-RTS

If an HE STA receives an MU-RTS Trigger frame, the HE STA shall commence the transmission of a CTS frame response at the SIFS time boundary after the end of a received PPDU when all the following conditions are met:

— The MU-RTS Trigger frame has one of the User Info fields addressed to the STA. The User Info field is addressed to a STA if the AID12 subfield is equal to the 12 LSBs of the AID of the STA and

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the MU-RTS Trigger frame is sent by the AP with which the STA is associated with or by the AP corresponding to the transmitted BSSID if STA has indicated support for receiving Control frames with TA set to the Transmitted BSSID (Rx Control Frame To MultiBSS set to 1 in HE Capabilities element).

— The UL MU CS condition indicates that the medium is idle (see 27.5.3.5 (UL MU CS mechanism)).

— The RU Allocation subfield in the User Info field addressed to the STA indicates primary 20 MHz channel, primary 40 MHz channel, primary 80 MHz channel,160 MHz channel, or 80+80 MHz channel.

Otherwise, the STA shall not send a CTS frame response.

NOTE—The ED-based CCA during the SIFS after receiving an MU-RTS Trigger frame and virtual CS functions are used to determine the state of the medium to respond to an MU-RTS Trigger frame. See 27.5.2.4 (UL MU CS mechanism) for details.

The CTS frame sent in response to an MU-RTS Trigger frame shall be carried in a non-HT or non-HT duplicate PPDU (see Clause 17).

A non-AP HE STA transmitting a CTS frame in response to an MU-RTS Trigger frame shall set the TXVECTOR parameter SCRAMBLER_INITIAL_STATE to the same value as the RXVECTOR parameter SCRAMBLER_INITIAL_STATE of the received MU-RTS Trigger frame. The data rate to be used for the non-HT or non-HT duplicate PPDU response shall be 6 Mb/s.

A CTS frame sent in response to an MU-RTS Trigger frame shall be transmitted on the 20 MHz channels indicated in the RU Allocation subfield of the User Info field of the MU-RTS Trigger frame.

The Power Management subfield in a CTS frame sent in response to an MU-RTS Trigger frame shall be set to 0.

NOTE—The subfields of the Frame Control field of a Control frame are set as illustrated in Figure 9-19. The More Data subfield is set to 0 in a CTS frame (see 9.2.4.1.8 (More Data subfield)).

Figure 27-3 (An example of an MU-RTS Trigger frame soliciting CTS frame responses on the primary 40 MHz channel) shows an example of the exchange of MU-RTS and simultaneous CTS frame responses on the primary 40 MHz channel. In this example, MU-RTS Trigger frame is transmitted in a 40 MHz non-HT duplicate PPDU on the primary 40 MHz channel. Further, the MU-RTS Trigger frame requests STA1 to

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transmit a CTS frame response in a non-HT PPDU on the primary 20 MHz channel and STA2 to transmit a CTS frame response in a 40 MHz non-HT duplicate PPDU on the primary 40 MHz channel.

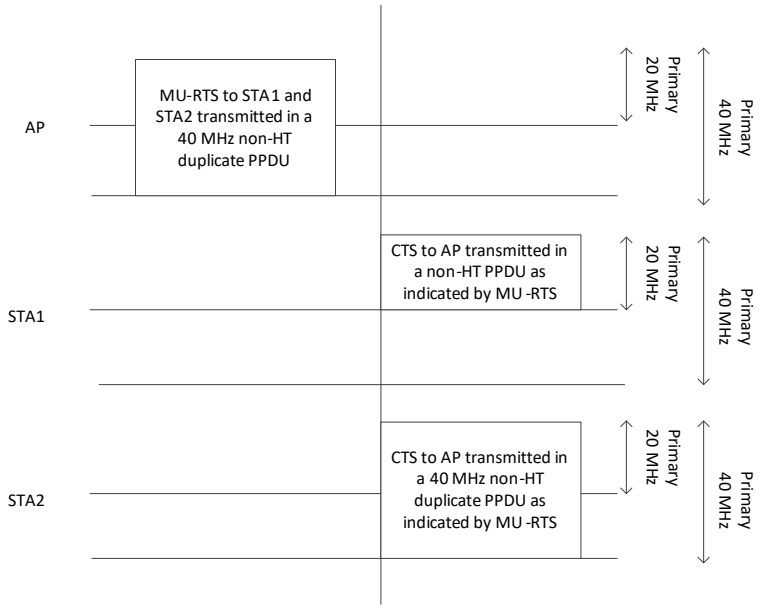


Figure 27-3—An example of an MU-RTS Trigger frame soliciting CTS frame responses on the primary 40 MHz channel

A STA that transmits a CTS frame in response to an MU-RTS Trigger frame shall follow the synchronization requirement defined in 17.3.9.10 (Pre-correction accuracy requirements).

27.2.6 Obtaining an EDCA TXOP for HE non-AP STAs using MU EDCA parameters

A STA that has not received an MU EDCA Parameter Set element from the AP to which it is associated does not follow the procedure described in this subclause.

A non-AP HE STA that receives a Basic Trigger frame that contains a User Info field addressed to the STA, and that receives an immediate response from the AP for the transmitted HE TB PPDU, shall update its CWmin[AC], CWmax[AC], AIFSN[AC] and HEMUEDCATimer[AC] state variables to the values contained in the most recently received MU EDCA Parameter Set element sent by the AP to which the STA is associated, for all the ACs from which QoS Data frames were transmitted successfully in the HE TB PPDU. The HEMUEDCATimer[AC] state variable is updated with the value contained in the MU EDCA Timer subfield of the MU EDCA Parameter Set element. The backoff counter maintenance corresponding to the updated state variables shall follow the rules in 10.22.2.2 (EDCA backoff procedure), and the updated HEMUEDCATimer[AC] shall start at the end of the immediate response.

In a non-AP HE STA, each HEMUEDCATimer[AC] shall uniformly count down without suspension to 0 when its value is nonzero.

NOTE 1—A non-AP STA that sends a frame to the AP with an OM Control field containing a value of 1 in the UL MU Disable field does not participate in UL MU operation. As such it is exempt from updating its EDCA access parameters to the values contained in the MU EDCA Parameter Set element as defined in this subclause.

NOTE 2—A non-AP STA that sends a QoS Data frame with Ack policy set to No Ack updates its state variables to the values contained in the MU EDCA Parameter Set element irrespective of receiving immediate response from the AP. The updated HEMUEDCATimer starts at the end of the HE TB PPDU.

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NOTE 3—A non-AP STA is not required to update its state variables to the values contained in the MU EDCA Parameter Set element when:

- The Trigger frame addressed to the STA is not a Basic Trigger frame
- The STA does not include QoS Data frames in the HE TB PPDU response sent in response to the Basic Trigger frame
- The STA transmits the HE TB PPDU in response to a Basic Trigger frame following the rules defined in 27.5.5 (UL OFDMA-based random access (UORA)).

NOTE 4—The TxOPLimit[AC] state variables are not updated by the procedure defined in this subclause, but in 10.22.2.8 TxOP limit.

A non-AP HE STA should only send QoS Data frames in an HE TB PPDU with ACs for which the STA's buffer queues contain frames that are only addressed to its associated AP.

When the HEMUEDCATimer[AC] of a non-AP HE STA reaches zero, then the STA may update the CWmin[AC], CWmax[AC] and AIFSN[AC] either to the values that are contained in the most recently received EDCA Parameter Set element sent by the AP to which the STA is associated, or to the values contained in the default dot11EDCATable if an EDCA Parameter Set element has not been received. An non-AP HE STA that sends a frame with OM Control field with the UL MU Disable subfield set to 1 as defined in 27.8.3 (Rules for transmit operating mode (TOM) indication) may set the HEMUEDCATimer[AC] for all its ACs to 0 on receiving an immediate acknowledegment from the OMI responder.

27.3 Fragmentation and defragmentation

27.3.1 General

An HE STA shall follow the fragmentation procedures defined in 10.2.7 (Fragmentation/defragmentation overview), 10.5 (Fragmentation), and 10.6 (Defragmentation). An HE STA may also support the dynamic fragmentation procedure defined in this subclause), which relaxes some of the rules defined in 10.2.7 to provide further flexibility in aggregating data to fit in a constrained payload duration (see 27.5 (MU operation)).

Subclauses 10.2.7 (Fragmentation/defragmentation overview) and 10.5 (Fragmentation) define the procedure to generate uniformly fragmented MSDU or MMPDU, where the length of each fragment is the same, except for the last fragment. These fragments are not allowed to be included in a A-MPDU under HT-immediate block ack agreements.

An HE STA can negotiate the use of different levels of dynamic fragmentation:

- Level 1: allows transmission or reception of one fragment at a time and does not need block ack agreement negotiation
- Level 2: allows transmission or reception of multiple fragments at a time, up to one per MSDU or A-MSDU, needs block ack agreement negotiation, and uses HT-immediate block ack signaling
- Level 3: allows transmission or reception of multiple fragments at a time, up to four per MSDU or A-MSDU, needs block ack agreement negotiation, and uses block ack signaling that is specific to dynamic fragmentation level 3

This subclause defines the procedure that generate non-uniformly fragmented MSDU, A-MSDU or MMPDU, where the length of each fragment is not required to be the same. The length of the first fragment shall be greater than or equal to the minimum fragment size indicated in the Minimum Fragment Size subfield of the HE Capabilities Information field in the HE Capabilities element sent by the recipient STA. If the length of the MSDU, A-MSDU or MMPDU is less than the minimum fragment size, then the MSDU, A-MSDU or MMPDU shall not be fragmented. We call dynamic fragments the fragments generated with dynamic fragmentation.

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In addition, these procedures allow the inclusion of these dynamic fragments within a S-MPDU, A-MPDU or multi-TID A-MPDUs under HT-immediate block ack agreements.

An HE STA follows the rules defined in 27.3.2 (Dynamic fragmentation) for generating these fragments.

27.3.2 Dynamic fragmentation

27.3.2.1 General

An originator STA transmitting an MPDU or A-MPDU that contains one or more dynamic fragments shall solicit an immediate response from the recipient STA for each of the fragments, except when the fragments are sent under level 3 dynamic fragmentation (see 27.3.2.4 (Level 3 dynamic fragmentation)). The originator STA shall transmit the fragments in order as defined in 10.5 (Fragmentation), except for level 3 dynamic fragmentation.

An HE STA may transmit dynamic fragments of an A-MSDU provided the A-MSDU Fragmentation Support subfield of the HE Capabilities element transmitted by the recipient is 1.

An originator STA may retransmit the full MSDU, A-MSDU or MMPDU when all the previously transmitted dynamic fragments of that MSDU, A-MSDU or MMPDU have explicitly failed at the receiving STA. An originator STA may retransmit a failed fragment when one or more of the previously transmitted fragments of that MSDU, A-MSDU, or MMPDU have explicitly failed at the receiving STA. The frame body length and contents of the retransmitted fragment shall be the same as the initially transmitted fragment and shall remain fixed for the lifetime of the MSDU, A-MSDU or MMPDU at that STA except when the all the fragments preceding the initial transmitted fragment were successfully received and all the fragments following the initial transmitted fragment have either failed or have not been transmitted, in which case the frame body length and contents of the retransmitted fragment may be different from the initially transmitted fragment.

A fragment has explicitly failed at the receiving STA if the originator STA successfully receives an immediate response that contains:

— A valid first MPDU that is not an Ack frame, BlockAck frame or Multi-STA BlockAck frame,

— A Multi-STA BlockAck frame with a BA Information field corresponding to the TID of the transmitted fragments is not present

— A BlockAck or Multi-STA BlockAck frame with a BA Information field that corresponds to the TID of the transmitted fragments is present and the bit in the BlockAck Bitmap field corresponding to the transmitted fragments is 0

An originator STA shall not transmit to a recipient STA an MPDU or A-MPDU containing dynamic fragments that do not satisfy the conditions in the subclauses below.

27.3.2.2 Level 1 dynamic fragmentation

An originator STA may transmit to a recipient STA an MPDU or S-MPDU that contains one dynamic fragment of an MMPDU or of an MSDU that is not sent under a block ack agreement if the recipient STA has indicated a value 1 in the HE Fragmentation Support field of its HE Capabilities element. An originator STA may transmit to a recipient STA an MPDU or S-MPDU that contains one dynamic fragment of an A-MSDU if the recipient STA has indicated a value of 1 in the A-MSDU Fragmentation Support field of its HE Capabilities element.

An originator STA may transmit to a recipient STA an MPDU or S-MPDU that contains one dynamic fragment of an MSDU that is sent under a block ack agreement if the following conditions are met:

— The HE Fragmentation Support field in the HE Capabilities element received from the STA is 1

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— For the block ack agreement associated with the TID of the MSDU, the ADDBA Extension element is present and the HE Fragmentation Operation subfield is 1 in the ADDBA Response frame received from the STA.

27.3.2.3 Level 2 dynamic fragmentation

An originator STA may transmit fragmented MMPDUs or MSDUs that are not sent under a block ack agreement to a recipient STA using level 1 and level 2 dynamic fragmentation if the HE Fragmentation Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element received from the STA is 2.

An originator STA may transmit fragmented MSDUs or A-MSDU if supported by the recipient under a block ack agreement to a recipient STA using level 2 dynamic fragmentation provided the following conditions are met:

— The HE Fragmentation Support field in the HE Capabilities element received from the STA is 2

— For the block ack agreement associated with the TID of the MSDU or A-MSDU, the ADDBA Extension element is present and the HE Fragmentation Operation subfield is 2 in the ADDBA Response frame received from the STA.

Using level 2 dynamic fragmentation, an originator STA may transmit to a recipient STA the following:

— One dynamic fragment of an MSDU, A-MSDU if supported by the recipient, or MMPDU in an MPDU or S-MPDU.

  • The originator STA follows the rules defined in 10.13.8 (Transport of S-MPDUs) for generating the S-MPDU.

— Up to one dynamic fragment of an MSDU or A-MSDU if supported by the recipient for each MSDU or A-MSDU and up to one dynamic fragment of an MMPDU in an A-MPDU format where the A-MPDU contains at least one dynamic fragment.

  • The originator STA follows the rules defined in 10.24.7.7 (Originator's behavior) for generating the A-MPDU and the rules defined in 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU) for generating the multi-TID A-MPDU (that can contain the fragment of the MMPDU).

27.3.2.4 Level 3 dynamic fragmentation

An originator STA may transmit fragmented MMPDUs or MSDUs that are not sent under a block ack agreement to a recipient STA using level 1 and level 3 dynamic fragmentation if the HE Fragmentation Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element received from the STA is 3.

An originator STA may transmit fragmented MSDUs or A-MSDU if supported by the recipient under a block ack agreement or fragmented MMPDU to a recipient STA using level 3 dynamic fragmentation provided the following conditions are met:

— The HE Fragmentation Support field in the HE Capabilities element received from the STA is 3

— For the block ack agreement associated with the TID of the MSDU or A-MSDU, the ADDBA Extension element is present and the HE Fragmentation Operation subfield is 3 in the ADDBA Response frame received from the STA.

The level 3 fragmentation allows multiple fragments of an MSDU or A-MSDU included in the same A-MPDU, reducing the fragments transmission delay. In the level 3 fragmentation, the block acknowledgment record maintains 4 bits per MSDU or A-MSDU (one bit for each fragment of the MSDU) if at least one MPDU's Fragment Number field is of nonzero value that solicits the immediate response in the received A-MPDU, otherwise 1 bit per MSDU.

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An originator STA may transmit to a recipient STA that has a value 3 in the HE Fragmentation Support field of its HE Capabilities element the following:

— One dynamic fragment of an MSDU, A-MSDU if supported by the recipient, or MMPDU in an MPDU or S-MPDU.

  • The originator STA shall follow the rules defined in 10.13.8 (Transport of S-MPDUs) for generating the S-MPDU.

— Up to four dynamic fragments of an MSDU or A-MSDU if supported by the recipient for each MSDU or A-MSDU, and up to one dynamic fragment of an MMPDU in an A-MPDU, where the A-MPDU contains at least one dynamic fragment.

  • The originator STA shall set the Fragment Number subfield of each MPDU to a value less than 4.
  • The originator STA shall follow the rules defined in 10.24.7.7 (Originator's behavior) for generating the A-MPDU with the exception that the A-MPDU shall contain MPDUs whose range of the Sequence Number subfields does not exceed $B_L/4$, where B_L is the length of the Block Ack Bitmap field of the BlockAck or Multi-STA BlockAck frame that corresponds to a TID of a transmitted fragment (see 10.24.7 (HT-immediate block ack extensions) and 27.4 (HE block acknowledgement procedure)).

27.3.3 Defragmentation

27.3.3.1 General

An HE STA shall set the HE Fragmentation Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element it transmits to 0 if it does not support dynamic fragments. Otherwise, the HE STA shall set the HE Fragmentation Support subfield as follows:

— Set to 1 if the STA supports reception of dynamic fragments following the procedure defined in 27.3.2.2 (Level 1 dynamic fragmentation)

— Set to 2 if the STA supports reception of dynamic fragments following the procedure defined in 27.3.2.3 (Level 2 dynamic fragmentation)

— Set to 3 if the STA supports reception of dynamic fragments following the procedure defined in 27.3.2.4 (Level 3 dynamic fragmentation)

An HE STA shall set dot11HEDynamicFragmentationLevel to the value of Fragmentation Support subfield of the HE Capabilities element it transmits if it supports reception of dynamic fragments.

Defragmentation of dynamic fragments shall follow the rules defined in 10.6 (Defragmentation) with the following exceptions:

— The recipient STA shall support the concurrent reception of dynamic fragments of a number of *outstanding* MSDUs and A-MSDUs when supported from the same transmitting STA that is equal to N_{max}, where N_{max} for MSDUs and A-MSDUs (if supported) is indicated in the Maximum Number of Fragmented MSDUs subfield of the HE Capabilities element transmitted by the STA. The term *outstanding* refers to an MPDU containing all or part of an MSDU or A-MSDU for which transmission has been started, and for which delivery of the MSDU or A-MSDU has not yet been completed (i.e., an acknowledgment of the final fragment has not been received and the MSDU, A-MSDU or MMPDU has not been discarded due to retries, lifetime, or for some other reason). The recipient STA shall support the concurrent reception of dynamic fragments of one outstanding MMPDU from a transmitting STA.

— The recipient STA may be subject to the receive timer rules for each of the MSDUs, A-MSDUs and MMPDUs defined in 10.6 (Defragmentation).

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A STA that has dot11AMSDUFragmentationOptionImplemented true shall set the A-MSDU Fragmentation Support subfield in the HE Capability element to 1. Otherwise, the STA shall set the A-MSDU Fragmentation Support subfield in the HE Capability element to 0.

An HE STA shall set the HE Fragmentation Operation subfield, if present, in the ADDBA Response frame to a value that is less than or equal to the value of HE Fragmentation Operation subfield, if present, in the received ADDBA Request frame.

27.3.3.2 Level 1 dynamic defragmentation

Upon reception of an MPDU or S-MPDU that carries a dynamic fragment, the recipient STA responds with an Ack frame or a Multi-STA BlockAck frame when the received fragment is contained in an MPDU or S-MPDU that solicits an immediate response. The receiver STA shall follow the rules defined in 10.3.2.9 (Ack procedure) for generating the Ack frame and the rules defined in 27.4 (HE block acknowledgement procedure) for generating the Multi-STA BlockAck frame that contains the acknowledgement for the soliciting S-MPDU that carries one dynamic fragment and carried in an HE TB PPDU.

27.3.3.3 Level 2 dynamic defragmentation

Upon reception of an MPDU or A-MPDU that carries one or more dynamic fragments, the recipient STA responds with one of the following frames:

— An Ack frame when the received fragment is contained in an MPDU or S-MPDU that solicits the immediate response. The recipient STA shall follow the rules defined in 10.3.2.9 (Ack procedure) for generating the Ack frame and the rules defined in 27.4 (HE block acknowledgement procedure) for generating the Multi-STA BlockAck frame that contains the acknowledgement for the soliciting S-MPDU carried in an HE TB PPDU or ack-enabled multi-TID A-MPDU.

— A BlockAck frame when the received fragments, up to one fragment for each MSDU or A-MSDU, are contained in an A-MPDU that solicits an immediate response. The recipient STA shall follow the rules defined in 10.24.7.5 (Generation and transmission of BlockAck frames by an HT STA or DMG STA) for generating the BlockAck frame and the rules in 27.4 (HE block acknowledgement procedure) for generating the Multi-STA BlockAck frame, except that the STA shall:

  - Set to 0 the LSB of the Fragment Number subfield in the Block Ack Starting Sequence Control subfield of the BlockAck frame or Multi-STA BlockAck frame that corresponds to a TID of a received fragment
  - Set to 1 each bit of the Block Ack Bitmap field that corresponds to a Sequence Number subfield and TID subfield of a successfully received fragment contained in the soliciting A-MPDU or multi-TID A-MPDU
  - Update the corresponding block ack record only when an MSDU or A-MSDU that is received in fragments is successfully reconstructed (see 10.6 (Defragmentation)). Otherwise, do not update the block ack record for that MSDU or A-MSDU.

A recipient STA shall discard any fragments that have been received during an HT-immediate block ack session for a TID if it receives a BlockAckReq frame from the originator STA for that TID when the fragments have a Sequence Number field value that is less than the value of the Starting Sequence Number field of the BlockAckReq frame or that have a sequence number that is less than *WinStartB* (see 10.24.7.6). The comparison of the two values is performed modulo 4096.

27.3.3.4 Level 3 dynamic defragmentation

Upon reception of an MPDU or A-MPDU that carries one or more dynamic fragments, the recipient STA responds with one of the following frames:

— An Ack frame when the received fragment is contained in an MPDU or S-MPDU that solicits the immediate response. The recipient STA shall follow the rules defined in 10.3.2.9 (Ack procedure)

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for generating the Ack frame and the rules defined in 27.4 (HE block acknowledgement procedure) for generating the Multi-STA BlockAck frame that contains the acknowledgement for the soliciting S-MPDU carried in an HE TB PPDU or ack-enabled multi-TID A-MPDU.

— A BlockAck frame when the received fragments, one or more fragments for each MSDU or A-MSDU, are contained in an A-MPDU where at least one MPDU's Fragment Number field is of non-zero value that solicits the immediate response. The recipient STA shall follow the rules in 10.24.7.5 (Generation and transmission of BlockAck frames by an HT STA or DMG STA) for generating the BlockAck frame, except that the STA shall:

- Set to 1 the LSB of the Fragment Number subfield in the Block Ack Starting Sequence Control subfield of the BlockAck frame or Multi-STA BlockAck frame that corresponds to a TID of a received fragment
- Set to 1 each bit in position *B* of the Block Ack Bitmap field that corresponds to a successfully received fragment and shall set it to 0 otherwise, with *B* calculated as:
  $B = 4 \times (SN - SSN) + FN$, where the operations on the sequence numbers are performed modulo 4096
  SN is the value of the Sequence Number subfield of an MPDU containing the fragment for which the receive status is indicated
  SSN is the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield of the BlockAck frame
  FN is the value in the Fragment Number subfield
- Update the corresponding block ack record only when an MSDU or A-MSDU that is received in fragments is successfully reconstructed (see 10.6 (Defragmentation)). Otherwise it shall not update the block ack record for that MSDU.

The recipient STA shall discard any fragments that have been received during an HT-immediate block ack session for a TID if it receives a BlockAckReq frame from the originator STA for that TID and the fragments have a Sequence Number field value that is less than the value of the Starting Sequence Number field of the BlockAckReq frame or that have a sequence number that is less than *WinStartB* (see 10.24.7.6) . The comparison of the two values is performed modulo 4096.

27.4 HE block acknowledgement procedure

27.4.1 Overview

The HE-immediate block acknowledge procedure builds on the features defined for HT-immediate block ack, with the following extensions:

— Support for a Multi-STA BlockAck frame

— Support for a Multi-STA BlockAckReq (MU-BAR)

— Support for a Multi-TID BlockAckReq frame

Additionally, the HE-immediate block acknowledgment procedure also added features such as:

— Acknowledging multiple STAs using a single Multi-STA BlockAck frame

— All-Ack, which uses a variant of Multi-STA BlockAck frame to acknowledge all MPDUs in the eliciting PPDU

— Pre-Association acknowledgment, which acknowledges pre-association management frames for multiple STAs using a single Multi-STA BlockAck frame

— Acknowledgment for single MPDUs (i.e., MPDU in an A-MPDU subframe with EOF = 1) of certain TIDs with multiple-MPDUs from other TIDs in a multi-TID A-MPDU using a single Multi-STA BlockAck frame

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An HE STA shall support generation of Compressed BlockAck frames if HT-immediate block ack is supported in the role of recipient (see 10.24.7.1 (Introduction)). An HE STA shall support generation of Multi-STA BlockAck frame if multi-TID A-MPDU operation (27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU)) is supported in the role of recipient. An non-AP HE STA shall support reception of a Multi-STA BlockAck frame.

A non-AP HE STA that is associated with an AP and that sends a Multi-STA BlockAck frame shall set the AID11 subfield in the Per AID TID Info field of the Multi-STA BlockAck frame to 0 and the RA field to the MAC address of the intended recipient.A non-AP HE STA that is not associated with an AP shall not send a Multi-STA BlockAck frame.

An HE AP that sends a Multi-STA BlockAck frame where the Per AID TID Info fields are addressed to more than one STA shall set the RA field to the broadcast address. An HE AP that sends a Multi-STA BlockAck frame where the Per AID TID Info fields are all addressed to a single recipient STA may set the RA field to either the address of the recipient STA or the broadcast address. An HE AP that sends a a Multi-STA BlockAck frame to an associated STA shall set the AID11 subfield in the Per AID TID Info field of the Multi-STA BlockAck frame to the 11 LSBs of the AID of the intended STA. An HE AP that sends a a Multi-STA BlockAck frame to an un-associated STA shall set the the AID11 subfield in the Per AID TID Info field of the Multi-STA BlockAck frame to 2045.

An HE STA that transmits a Multi-STA BlockAck frame shall use a rate, HT MCS, <VHT-MCS, NSS> tuple or <HE-MCS, NSS> tuple that is supported by all recipient STAs.

A non-AP HE STA that has established a block ack agreement with an HE STA shall examine each BA Information field received in the Multi-STA BlockAck frame from the HE STA and shall process each BA information according to the procedure defined in 27.4.2 (Acknowledgement context in a Multi-STA Block-Ack frame).

A non-AP HE STA that has not established a block ack agreement with an HE STA shall examine each BA Information field received in the Multi-STA BlockAck frame as follows:

— If the Ack Type field is 1, then the Per AID TID Info field indicates either the acknowledgement of a single MPDU (i.e., MPDU in an A-MPDU subframe with EOF = 1) identified by the value of the TID, or a single MPDU (i.e., MPDU in an A-MPDU subframe with EOF = 1) that is an Action frame or a PS-Poll frame when the TID field is set to 15. The BA Information field is intended to the STA if the AID of the BA Information field contains the STA's AID, and is processed according to the procedure defined in 27.4.2 (Acknowledgement context in a Multi-STA BlockAck frame).

— If the Ack Type field is 0, the AID field is set to 2045, and the TID field is 15, then the RA field is the MAC address of an unassociated STA for which the Per AID TID Info subfield is intended. The BA Information field is intended to the STA if the RA field of the BA Information field contains the STA's MAC address, and is processed according to the procedure defined in 27.4.2 (Acknowledgement context in a Multi-STA BlockAck frame).

An HE AP shall not send to the STA a Multi-STA BlockAck frame that has Per STA Info fields for STAs associated with more than one BSS in a multiple BSSID set unless the HE AP has received from the STA an HE Capabilities element with the Rx Control Frame To MultiBSS subfield in HE MAC Capabilities Information field set to 1.

An AP that transmits a Multi-STA BlockAck frame addressed to HE STAs shall set the TA field of the frame to the MAC address of the AP, except when dot11MultiBSSIDActivated is true and the Multi-STA BlockAck frame is directed to STAs from at least two different BSSs of the multiple BSSID set, in which case, the AP shall set the TA field of the frame to the transmitted BSSID.

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A non-AP HE STA that is associated with a BSS corresponding to a nontransmitted BSSID and has indicated support for receiving Control frames with TA set to the Transmitted BSSID (via the Rx Control Frame To MultiBSS subfield set to 1 in HE Capabilities element that it transmits) shall, upon receiving an MU BAR Control frame with TA set to the transmitted BSSID, respond to an MU-BAR Trigger frame with RA set either to the (nontransmitted) BSSID of the BSS it is associated with or the transmitted BSSID (i.e., the TA of the soliciting MU-BAR Trigger frame).

An HE STA that transmits a Multi-TID BlockAckReq frame shall contains the TID Values of the Per TID Info subfields of the BAR Information field of the Multi-TID BlockAckReq frame for the MPDUs of which TIDs correspond to AC that has the same or higher priority with respect to the primary AC, except when the Multi-TID BlockAckReq frame is carried in an HE TB PPDU in which case the HE STA contains the TID Values of the Per TID Info subfields of the BAR Information field of the Multi-TID BlockAckReq frame for the MPDUs of which TIDs correspond to any AC.

An HE STA that transmits a BlockAckReq frame carried in an HE TB PPDU contains the TID Values of the Per TID Info subfields of the BAR Information field of the BlockAckReq frame for the MPDUs of which TIDs correspond to any AC.

27.4.2 Acknowledgement context in a Multi-STA BlockAck frame

A recipient of an S-MPDU, or A-MPDU, or a multi-TID A-MPDU sets the Ack Type and TID subfields in the AID TID Info field of the Multi-STA BlockAck frame sent as a response depending on the acknowledgement context as follows:

- An HE AP that receives an S-MPDU prior to association may generate a Multi-STA BlockAck frame using the procedure described in pre-association ack context.
- The recipient of single-TID A-MPDU may generate a Multi-STA BlockAck frame as follows:
  - If all MPDUs in the AMPDU are received successfully, then the recipient may follow the procedure described in the All Ack context. Otherwise, the recipient may follow the procedure described in the BlockAck context.
- The recipient of multi-TID A-MPDU shall generate a Multi-STA BlockAck frame as follows:
  - If all MPDUs in the multi-TID AMPDU are received successfully, then the recipient may follow the procedure described in the All Ack context
  - Otherwise, for each TID included the received multi-TID A-MPDU,
    - If the EOF delimiter field of the non-zero length MPDU is set to 1, the recipient shall create a per AID TID info field using the procedure described in Ack context
    - If the EOF delimiter field of the non-zero length MPDU is set to 0, the recipient shall create a per AID TID info field using the procedure described in BlockAck context

The procedure for different acknowledgment context for generating Multi-STA BlockAck frame is defined below:

a) All Ack context: if the originator had set the All Ack Support subfield in the HE Capabilities element to 1, then the recipient may set the Ack Type field to 1 and the TID subfield to 14 to indicate the successful reception of all the MPDUs carried in the eliciting A-MPDU or multi-TID A-MPDU. Otherwise the recipient shall not set the Ack Type field to 1 and the TID subfield to 14. The Multi-STA BlockAck frame shall contain only one Per AID TID Info field addressed to an originator in the Multi-STA BlockAck frame.

b) Pre-association ack context: A recipient receiving a single MMPDU from the unassociated STA, that requires an acknowledgment, shall set the Ack Type field to 0, AID subfield to 2045, and the TID field to 15 in the Per AID TID Info field, and the BA information set to the intended recipient's MAC address to indicate the successful reception of that MMPDU.

c) Ack context: If the recipient had set the Ack-Enabled A-MPDU Support subfield in the HE Capabilities element to 1, then the recipient receiving a single MPDU (i.e., MPDU in an A-MPDU subframe

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with EOF = 1), that requires an acknowledgment, shall set the Ack Type field to 1 and the TID field to the TID value of that MPDU to indicate the successful reception of that MPDU or to the TID value of 15 to indicate the successful reception of the MPDU that is an Action frame or PS-Poll frame.

If a received multi-TID A-MPDU contains one or more MPDUs where each MPDU corresponds to a unique TID and has the EOF subfield set to 1 in the preceding nonzero length MPDU delimiter, solicits an immediate acknowledgment, then the Multi-STA BlockAck frame may contain multiple occurrences of unique AID TID Info fields, with Ack Type field equal to 1, one for each such successfully received MPDU requesting an acknowledgment.

The allowed values for the TID field in this context are 0 to 7 (for indicating acknowledgement of QoS Data or QoS Null frames) or 15 (for indicating acknowledgement of an Action frame or a Management frame sent by the unassociated HE STA, e.g., Association Request).

d) BlockAck context: The recipient shall set the Ack Type field to 0 and the TID field of a Per AID TID Info field to the TID value of MPDUs requesting block acknowledgement that are carried in the eliciting A-MPDU or multi-TID A-MPDU.

The Multi-STA BlockAck frame may contain multiple occurrences of these Per AID TID Info fields addressed to an originator, one for each MPDU that is requesting block acknowledgement, in which case the Block Ack Starting Sequence Control and Block Ack Bitmap fields shall be set according to 10.24.7 (HT-immediate block ack extensions) for each block ack session, and according to 27.3 (Fragmentation and defragmentation) for each block ack session with dynamic fragmentation.

The allowed values for the TID field in this context are 0 to 7 (for indicating block acknowledgement of QoS Data frames).

Variable bitmap lengths can be included in the Per AID TID Info field when the originator and recipient negotiate their use as defined in 27.4.3 (Negotiation of block ack bitmap lengths).

Upon reception of the Multi-STA BlockAck frame the originator shall examine each Per AID TID Info field and shall perform the following operations for each Per AID TID Info field that has an AID field addressed to the originator (i.e., the AID subfield is an AID if the originator is a non-AP STA, is 0 when the originator is an AP, and is 2045 when the originator is an unassociated HE STA):

— If the Ack Type field is 0 and the TID field is less than 8 then the BlockAck Starting Sequence Control, TID and BA Bitmap fields of the Per AID TID Info field are processed according to 10.24.7 (HT-immediate block ack mechanism), 27.3 (Fragmentation and defragmentation), and as defined below.

— If the Ack Type field is 0 and the TID field is 15, then the Per AID TID Info field indicates the acknowledgement of a single MMPDU sent by the unassociated STA as defined by the acknowledgement context.

— If the Ack Type field is 1 and the TID is less than or equal to 7 or is equal to 15, then the Per AID TID Info field indicates the acknowledgement of a single MPDU (i.e., MPDU in an A-MPDU subframe with EOF = 1) identified by the value of the TID, an Action frame or a PS-Poll frame.

— If the Ack Type field is 1 and the TID subfield of AID TID Info field is 14, then the Per AID TID Info field indicates the acknowledgement of all MPDUs carried in the eliciting PPDU as defined by the acknowledgement context.

27.4.3 Negotiation of block ack bitmap lengths

Both the Compressed BlockAck frame and Multi-STA BlockAck frame allow different Block Ack Bitmap subfield lengths. The length of the Block Ack Bitmap subfield is indicated in the Fragment Number subfield

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of the Block Ack Starting Sequence Control field as defined in 9.3.1.9 (BlockAck frame format). The Block Ack Bitmap subfield length in bits of a BlockAck frame used during a BA session depends on the negotiated buffer size between the originator and the recipient as indicated below:

— When a Compressed BlockAck frame is used:
  - If the negotiated buffer size is within [1, 64] then a BlockAck Bitmap length of 64 shall be used during the BA session
  - If the negotiated buffer size is within [65, 256] then a BlockAck Bitmap length of either 64 or 256 shall be used during the BA session

— When a Multi-STA BlockAck frame is used:
  - If the negotiated buffer size is within [1, 64] then a BlockAck Bitmap length of either 32 or 64 shall be used during the BA session
  - If the negotiated buffer size is within [65, 128] then a BlockAck Bitmap length of 32, 64 or 128 shall be used during the BA session
  - If the negotiated buffer size is within [129, 256] then a BlockAck Bitmap length of 32, 64, 128 or 256 shall be used during the BA session

The recipient shall not include in the Buffer Size field of an ADDBA Response frame a value that would cause the BlockAck Bitmap length of its block ack responses to exceed the BlockAck Bitmap length that is derived by the Buffer Size field of the ADDBA Request frame sent by the originator. When the Buffer Size field in the ADDBA Request frame is set to 0, the Buffer Size field of an ADDBA Response frame is within [1, 64]. The originator sets the Duration field value accounting for the largest BlockAck Bitmap length based on negotiated buffer size.

A recipient shall not include in a Multi-STA BlockAck frame a Per AID TID Info field with a 32-bit BlockAck Bitmap field addressed to an originator if the 32-bit BA Bitmap Support field in the HE MAC Capabilities Information field in the HE Capabilities element received from that originator is 0.

NOTE—A Multi-STA BlockAck frame might include Per AID TID Info fields with a 32-bit BlockAck Bitmap field addressed to other originators and the nonsupporting originator needs to able to parse these fields to locate a possible Per AID TID Info field addressed to it.

A recipient that is the intended receiver of an (multi-TID) A-MPDU, (multi-TID) BlockAckReq frame, MU-BAR Trigger frame or GCR MU-BAR Trigger frame that solicits an immediate BlockAck frame response for each TID shall follow the rules defined in 10.24.7 (HT-immediate block ack extensions) except that:

— *WinSizeR* is set to the smaller of *BitmapLength* and the value of the Buffer Size field of the associated ADDBA Response frame that established the block ack agreement, where the *BitmapLength* is the largest value for the BlockAckBitmap that is supported by the recipient

— The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield shall be set to any value in the range from ($WinEnd_R - BitmapLength + 1$) to $WinStart_R$

— The values in the recipient's record of status of MPDUs beginning with the MPDU for which the Sequence Number subfield value is equal to $WinStart_R$ and ending with the MPDU for which the Sequence Number subfield value is equal to $WinEnd_R$ shall be included in the BlockAck Bitmap, wherein the length of the BlockAck Bitmap field shall be greater than or equal to $WinEnd_R - WinStart_R$

NOTE—An HE STA can generate a BlockAck frame with variable length Block Ack Bitmap field in which case the STA ensures that the BlockAck frame response fits within the remaining duration of the TXOP.

If a STA sets the HE Fragmentation Support subfield in the HE Capabilities element to 3, then the LSB of the Fragment Number subfield of the BA frame may be set to 1. If the LSB of the Fragment Number subfield of the BA frame is set to 1, then the BA Bitmap fields are re-mapped as defined in 27.3 (Fragmentation and defragmentation).

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27.4.4 Per-PPDU acknowledgment selection rules

27.4.4.1 General

A STA that sends a PPDU to an intended recipient can solicit different immediate responses by using the Ack Policy field of QoS Data or QoS Null frames, the type of the frame (e.g., Action, (multi-TID) BAR, MU-BAR Trigger frame, GCR MU-BAR Trigger frame, etc.) and the EOF field setting.

27.4.4.2 Responding to an HE SU PPDU with an SU PPDU

An HE STA that receives an HE SU PPDU with an A-MPDU that contains QoS Data or QoS Null frames addressed to it shall follow the following acknowledgment procedure:

1) If the HE SU PPDU carries an S-MPDU that is a QoS Data frame or QoS Null frame with the Ack Policy field equal to Normal Ack, or an Action Ack frame, then the STA shall respond with an Ack frame carried in an SU PPDU.
2) If the HE SU PPDU carries a single-TID A-MPDU that includes one or more QoS Data frame or QoS Null frame with EOF = 0, and with the Ack Policy field equal to Implicit Block Ack Request for at least one MPDU, then the STA shall respond with a Compressed BlockAck frame as defined in 10.24.7.5 (Generation and transmission of BlockAck frames by an HT STA or DMG STA), carried in an SU PPDU.
3) If the HE SU PPDU carries a multi-TID A-MPDU that includes more than one QoS Data frame or QoS Null frame with the Ack Policy field equal to Implicit Block Ack Request and with more than one TID, then the STA shall respond with a Multi-STA BlockAck frame as defined in 27.4.2 (Acknowledgement context in a Multi-STA BlockAck frame), carried in an SU PPDU.

27.4.4.3 Responding to an HE MU PPDU with an SU PPDU

If an AP intends to solicit an immediate response in an SU PPDU the following apply:

— An AP shall set the Ack Policy field of the QoS Data and QoS Null frames to Normal Ack or Implicit Block Ack Request in at most one A-MPDU in the HE MU PPDU (see 10.3.2.10.1 (Acknowledgement procedure for DL MU PPDU in SU format) for an example of this sequence).

— The A-MPDUs in the HE MU PPDU shall not contain an Action frame or an MMPDU that solicits a response.

A non-AP STA that receives an HE MU PPDU with an A-MPDU that contains QoS Data or QoS Null frames addressed to it with the Ack Policy field equal to Normal Ack or Implicit Block Ack Request shall follow the following acknowledgment procedure:

1) If the HE MU PPDU carries an S-MPDU that is a QoS Data frame or QoS Null frame addressed to it and with the Ack Policy field equal to Normal Ack, then the STA shall respond with an Ack frame carried in an SU PPDU.
2) If the HE MU PPDU carries a single TID A-MPDU that includes one or more QoS Data frame or QoS Null frame with EOF = 0 and with the Ack Policy field equal to Implicit Block Ack Request for at least one MPDU, then the STA shall respond with a Compressed BlockAck frame as define in 10.24.7.5, carried in an SU PPDU.
3) If the HE MU PPDU carries a multi-TID A-MPDU that includes more than one QoS Data frame or QoS Null frame addressed to it with the Ack Policy field equal to Implicit Block Ack Request and with more than one TID, then the STA shall respond with a Multi-STA BlockAck frame as defined in 27.4.2 (Acknowledgement context in a Multi-STA BlockAck frame), carried in an SU PPDU.

NOTE—A control response frame carried in an SU PPDU that is an immediate response to an HE MU PPDU follows the rules defined in 10.7.6.5 (Rate selection for control response frames).

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27.4.4.4 Responding to an HE MU PPDU or HE SU PPDU with an HE TB PPDU

An AP that sends an HE MU PPDU or HE SU PPDU that solicits an immediate response carried in an HE TB PPDU shall set the Ack Policy to HTP Ack for each of the MPDUs for which it intends to solicit an immediate response (see 10.3.2.10.2 (Acknowledgement procedure for DL MU PPDU in MU format) for an example of this sequence). If an Action frame or an MMPDU that solicits an immediate acknowledgement is carried in an HE MU PPDU, then the response is carried in an HE TB PPDU. A non-AP STA that receives an HE MU PPDU or HE SU PPDU with an A-MPDU that contains QoS Data or QoS Null frames addressed to it with Ack Policy field equal to HTP Ack, or an Action-Ack frame shall not respond if it has not received the UL resource allocation information either through UMRS Control field or a Trigger frame in the soliciting PPDU.

A non-AP STA that receives an HE MU PPDU or HE SU PPDU with an A-MPDU that contains QoS Data or QoS Null frames addressed to it with Ack Policy field equal to HTP Ack, or an Action-Ack frame shall follow the following acknowledgment procedure if it has received the UL resource allocation information through either a UMRS Control field or a Trigger frame in the soliciting PPDU:

1) If the HE MU PPDU or HE SU PPDU carries an S-MPDU that is a QoS Data frame or QoS Null frame with the Ack Policy field equal to HTP Ack or an Action frame, and if a UMRS Control field is present, then the STA shall respond with an Ack frame carried in the HE TB PPDU sent as a response.
2) If the HE MU PPDU or HE SU PPDU carries a single TID A-MPDU that includes one or more QoS Data frames or QoS Null frames with EOF = 0, with the Ack Policy field equal to HTP Ack for at least one MPDU, and either a Trigger frame or a frame with a UMRS Control field is present, then the STA shall respond with a Compressed BlockAck frame carried in the HE TB PPDU sent as a response.
3) If the HE MU PPDU or HE SU PPDU carries a multi-TID A-MPDU that includes QoS Data frames or QoS Null frames with the Ack Policy field equal to HTP Ack, and an Action Ack frame, and either a Trigger frame or a frame with a UMRS Control field is present, then the STA shall respond with a Multi-STA BlockAck frame carried in the HE TB PPDU sent as a response.

27.4.4.5 Responding to an HE TB PPDU with a DL SU PPDU

A non-AP STA that sends an HE TB PPDU as a response to a Basic Trigger frame that solicits an immediate response shall set the Ack Policy to Normal Ack/Implicit Block Ack Request (see 10.3.2.10.3 (Acknowledgement procedure for an UL MU transmission) for an example of this sequence). If the HE AP intends to send the response in a DL SU PPDU format, then the HE AP shall follow the following acknowledgment procedure:

1) If the HE TB PPDU carries an S-MPDU from a single STA that solicits an immediate response, then the HE AP shall respond with either an Ack frame or a Multi-STA BlockAck frame with the Ack Type field set to 1 carried in a DL SU PPDU format.
2) If the HE TB PPDU carries a single TID A-MPDU from a single STA that solicits an immediate response, then the HE AP shall respond with a Compressed BlockAck frame, a Multi-STA BlockAck with the Ack Type field set to 1 and the TID field set to 14 or a Multi-STA BlockAck frame with the Ack Type field set to 0 carried in a DL SU PPDU format.
3) If the HE TB PPDU carries a multi-TID A-MPDU that solicits an immediate response from a single STA then the HE AP shall respond with a Multi-STA BlockAck frame with the Ack Type field set to 0 carried in a DL SU PPDU format.

If the HE TB PPDU carries S-MPDUs, A-MPDUs, or multi-TID A-MPDUs from more than one STA, or a combination of S-MPDUs from a subset of STAs, A-MPDUs from another subset of STAs, or multi-TID A-MPDUs from another subset of STAs then the AP shall respond with a Multi-STA BlockAck frame carried

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in a DL SU PPDU format that contains the appropriate settings in each Per AID TID Info field intended to each STA as defined in the previous subclauses.

27.4.4.6 Responding to an HE TB PPDU with an HE MU PPDU

A non-AP STA that sends an HE TB PPDU as a response to a Basic Trigger frame that solicits an immediate response shall set the Ack Policy to Normal Ack/Implicit Block Ack Request for each of the MPDUs carried in the A-MPDU (see 10.3.2.10.3 (Acknowledgement procedure for an UL MU transmission) for an example of this sequence). If the HE AP intends to send the response in an OFDMA HE MU PPDU format, then the HE AP shall follow the following acknowledgment procedure:

a) If the HE TB PPDU carries an S-MPDU from more than one STA, or (multi-TID) A-MPDU from more than one STA, or a combination of an S-MPDU from some STAs and (multi-TID) A-MPDU from other STAs, then the HE AP shall do one of the following:

   - The AP shall respond with an Ack frame to each of the STAs from which an S-MPDU that solicited an immediate response was received, and with a Compressed BlockAck frame to each of the STAs from which an A-MPDU that solicited an immediate response was received, or a Multi-STA BlockAck frame to each of the STAs from which a multi-TID A-MPDU that solicited an immediate response was received. The control response frame for each STA shall be sent in the allocated RU that is identified by the AID of each STA.
   - The AP may respond with group addressed Multi-STA BlockAck frame(s) in an HE MU PPDU if the receivers of group-addressed Multi-STA BlockAck frame support the reception of MU Multi-STA BlockAck frame by Group Addressed Multi-STA BlockAck In DL MU Support in DL MU Support subfield in the HE MAC Capabilities Information field The Ack Type field shall be set according to the acknowledgement context. An HE AP should only transmit a group addressed Multi-STA BlockAck frame in an HE MU PPDU to a non-AP HE STA *n* on the broadcast RU (26/52/106/242/484/996) (see 28.3.10.8.6 (HE-SIG-B per-user content)) that includes the RU used for receiving the immediately preceding HE TB PPDU from STA *n*. There shall be no more than one group addressed Multi-STA BlockAck frame carried in a broadcast RU of the HE MU PPDU.

27.4.5 HE block acknowledgment request and response rules

An HE AP may solicit BlockAck frame responses from multiple HE STAs using an MU-BAR Trigger frame or GCR MU-BAR Trigger frame. The MU-BAR Trigger frame shall contain either Compressed BlockAckReq variant or Multi-TID BlockAckReq variant in each of the Per User Info fields. An HE AP shall not send a Multi-TID BlockAckReq (neither as part of a Per User Info field intended to the STA in an MU-BAR Trigger frame nor as a BAR frame) to a STA that has not indicated support for multi-TID A-MPDU. (Multi-TID) BlockAckReq, BlockAckReq, GCR MU-BAR Trigger, and MU-BAR Trigger frames indicate the length of the solicited block ack responses according to the FN settings defined in 9.3.1.9 (BlockAck frame format). An HE STA that receives a Multi-TID A-MPDU that solicits an immediate response shall send the acknowledgement using a Multi-STA BlockAck frame. An HE STA that receives a single-TID A-MPDU in an HE SU PPDU that solicits an immediate response shall send the acknowledgement using a Compressed BlockAck frame.

An HE STA that receives a BlockAckReq frame or an MU-BAR Trigger frame that contains a Compressed BlockAckReq variant in the User Info field addressed to the STA, or a GCR MU-BAR Trigger frame that contains a Compressed BlockAckReq variant in the Common Info field shall respond with a Compressed BlockAck frame as defined in 10.24.7 (HT-immediate block ack extensions) or a Multi-STA BlockAck frame as defined in 27.4 (HE block acknowledgement procedure), with Starting Sequence Number subfield set to the Starting Sequence Number subfield of the Block Ack Request Starting Sequence Control subfield and the length of the Block Ack Bitmap subfield calculated as defined in 27.4.3 (Negotiation of block ack bitmap lengths).

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An HE STA that receives a Multi-TID BlockAckReq frame or an MU-BAR Trigger frame that contains a Multi-TID BlockAckReq variant in the User Info field addressed to the STA or a GCR MU-BAR Trigger frame that contains a Multi-TID BlockAckReq variant in the Common Info field shall respond with a Multi-STA BlockAck frame that contains a Per AID TID Info field with a Block Ack Bitmap subfield for each of the TIDs (with values less than 8) contained in the BlockAckReq frame, with Starting Sequence Number subfield set to the Starting Sequence Number subfield of the Block Ack Request Starting Sequence Control subfield and the length of the Block Ack Bitmap subfield calculated as defined in 27.4.3 (Negotiation of block ack bitmap lengths).

27.5 MU operation

27.5.1 HE DL MU operation

27.5.1.1 General

HE DL MU operation allows an AP to transmit simultaneously to one or more non-AP STAs in DL OFDMA, DL MU-MIMO or both.

The PSDU on each RU in an HE MU PPDU shall be padded to end at the same time, indicated by the L-SIG field as described in 28.3.10.5 (L-SIG).

The padding procedure for each A-MPDU in an HE MU PPDU is defined in 27.10.2 (A-MPDU padding for an HE SU PPDU, HE ER SU PPDU and HE MU PPDU).

A STA shall not transmit an HE MU PPDU of DL MU-MIMO with OFDMA allocated in an RU that is addressed to a STA unless the AP has received from the STA an HE Capabilities element with the Partial Bandwidth DL MU-MIMO subfield in the HE PHY Capabilities Information field equal to 1.

An AP shall not send to a STA an A-MPDU contained in an HE MU PPDU that contains one of the following combinations of frames unless the AP has received from the STA an HE Capabilities element with the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field equal to 1:

— A QoS Data frame with Ack Policy field set to HTP Ack carried in an A-MPDU subframe with the EOF field set to 1 and a Trigger frame.

— A Management frame carried in an A-MPDU subframe with the EOF field set to 1 where the Management frame is a Disassociation frame, Re(Association) Response frame, Authentication frame or Action frame, and a Trigger frame.

27.5.1.2 RU addressing in an HE MU PPDU

The Type and Subtype subfields in the Frame Control field and address type (individually addressed or group addressed) of MPDUs may be different across A-MPDUs in different RUs within the same HE MU PPDU.

An AP shall set one or more elements in the TXVECTOR parameter array STA_ID_LIST, which represents the list of STAs that are the recipients of the transmitted HE MU PPDU as described in 27.11.1 (STA_ID_LIST). A STA_ID_LIST element with a particular value shall not appear more than once in the array except is the value is 2046, which identifies an unallocated RU. If an AP sets the TXVECTOR parameter STA_ID_LIST to match the 11 LSBs of the AID of a non-AP STA, then the non-AP STA may disregard any broadcast RU in the same HE MU PPDU.

An MPDU of an HE MU PPDU sent in a broadcast RU shall not include information intended for a STA that is identified as the recipient of another RU in the same HE MU PPDU.

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27.5.2 HE bandwidth query report operation for MU

A STA may send bandwidth query reports (BQRs) when the peer STA has indicated support by setting the BQR Support field in the HE Capabilities element it transmits to 1; otherwise the STA shall not send BQRs to the peer STA.

An AP may solicit BQRs from a non-AP STA with a BQRP Trigger frame if the non-AP STA has indicated support by setting the BQRP Support field in the HE Capabilities eement it transmits to 1; otherwise the AP shall not solicit BQRs from the non-AP STA.

A non-AP STA reports its channel availability information (unsolicited BQR) to the AP to which it is associated using the BQR Control field of frames it transmits as defined below:

— The HE STA may report the channel availability information in the BQR Control field of frames it transmits if the AP has indicated its support in the BQR Support subfield of its HE Capabilities element; otherwise the STA shall not report the channel availability information in the BQR Control field.

NOTE—The STA can send an unsolicited BQR in response to certain Trigger frames except MU-RTS and BQRP (with or without random access RUs, as defined in 27.5.3.3 (STA behavior for UL MU operation) and in 27.5.5 (UL OFDMA-based random access (UORA))) or it can send the unsolicited BQR after accessing the WM using EDCA.

A STA may send BQRs to an AP to assist DL MU and UL MU resource allocation in an efficient way. The non-AP STA may either implicitly deliver BQRs in the BQR Control field of a frame transmitted to the AP (unsolicited BQR) or explicitly deliver BQRs in any frame sent to the AP in response to a BQRP Trigger frame (solicited BQR).

A non-AP STA reports its channel availability information (unsolicited BQR) to the AP to which it is associated using the BQR Control field of frames it transmits as defined below:

— The HE STA may report the channel availability information as specified in 28.3.19.6.5 (Per 20 MHz CCA sensitivity) in the BQR Control field of frames it transmits if the AP has indicated its support in the BQR Support subfield of its HE Capabilities element; otherwise the STA shall not report the channel availability information in the BQR Control field.

An HE AP may solicit one or more non-AP HE STAs that support generating BQRs, by sending a BQRP Trigger frame (see 9.3.1.23 (Trigger frame format)). A non-AP STA that supports generating a BQR responds (solicited BQR) as defined below:

— The STA that receives a BQRP Trigger frame shall follow the rules defined in 27.5.3.3 (STA behavior for UL MU operation) to generate the HE TB PPDU when the Trigger frame contains the STA's AID in any of the Per User Info fields; otherwise the STA shall follow the rules defined in 27.5.5 (UL OFDMA-based random access (UORA)) to gain access to a random access RU and generate the HE TB PPDU when the Trigger frame contains one or more random access RUs.

— The STA shall include in the HE TB PPDU one or more QoS Null or Action No Ack frames containing the BQR Control field with the channel availability information of the STA. The HE STA shall not solicit an immediate response for the frames carried in the HE TB PPDU (e.g., by setting the Ack Policy subfield of the frame to Normal Ack or Implicit Block Ack Request).

An AP may include a BQRP Trigger frame together with other control, data and management frames in one A-MPDU to a STA if the HE Capabilities element received from the STA has the BSRP BQRP A-MPDU Aggregation field equal to 1. If a STA receives a BQRP Trigger frame aggregated with control, data and management frames that solicits an acknowledgement, the response A-MPDU shall contain MPDUs in the order described in Table 9-428 (A-MPDU contents MPDUs in the control response context).

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27.5.3 UL MU operation

27.5.3.1 General

UL MU operation allows an HE AP to solicit simultaneous immediate response frames from one or more non-AP HE STAs. Non-AP HE STAs shall attempt to transmit their response frames using the HE TB PPDU format except when the Trigger frame is of type MU-RTS, in which case the response (CTS) is sent in a non-HT PPDU format (see 27.2.5 (MU-RTS/CTS procedure)).

A non-AP HE STA with dot11ULMUMIMOOptionImplemented true shall set the Full Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field of the HE Capabilities element it transmits to 1, if it supports receiving a Trigger frame soliciting an HE TB PPDU that uses UL MU-MIMO within an RU that spans the entire PPDU bandwidth. Otherwise, the HE STA shall set the Full Bandwidth UL MU-MIMO subfield to 0.

A non-AP HE STA with dot11ULMUMIMOOptionImplemented true shall set the Partial Bandwidth UL MU-MIMO subfield in the HE PHY Capabilities Information field of the HE Capabilities element it transmits to 1, if it supports receiving a Trigger frame soliciting an HE TB PPDU that uses UL MU-MIMO within an RU that does not span the entire PPDU bandwidth. Otherwise, the HE STA shall set the Partial Bandwidth UL MU-MIMO subfield to 0.

A non-AP HE STA with dot11ULMUMIMOOptionImplemented equal to true is referred to as an UL MU capable STA.

A non-AP HE STA shall set the UMRS Support subfield of the HE Capabilities element it transmits to 1 if its dot11HEULMUResponseSchedulingOptionImplemented is true; otherwise the STA shall set it to 0.

An HE AP shall not transmit a Trigger frame soliciting an HE TB PPDU that uses UL MU-MIMO within an RU that does not span the entire PPDU bandwidth to a STA from which it has not received an HE Capabilities element with the Partial Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field equal to 1.

An HE AP shall not transmit a Trigger frame soliciting an HE TB PPDU that uses UL MU-MIMO within an RU that spans the full bandwidth to a non-AP HE STA from which it has not received an HE Capabilities element with the Full Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field equal to 1.

A non-AP HE STA transmitting an HE TB PPDU(shall operate as either a class A or class B device as defined in 28.3.14 (Transmit requirements for an HE TB PPDU). An HE STA indicates its device class in the Device Class subfield in the HE PHY Capabilities Information field of the HE Capabilities elements that it transmits.

An HE AP shall finish configuration to its receiver module with the parameters of TRIGVECTOR carried by PHY-TRIGGER.request primitive to receive HE TB PPDUs from triggered STAs before HE TB PPDU arrivals.

27.5.3.2 Rules for soliciting UL MU frames

27.5.3.2.1 General

An AP shall not send a frame that contains a UMRS Control subfield to a STA that has not set the UMRS Support subfield to 1 in the HE MAC Capabilities Information field of the HE Capabilities element it transmits.

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An AP that transmits a PPDU may solicit an HE TB PPDU from one or more STAs through one of the following mechanisms:

— Including in the PPDU one or more Trigger frames that include one or more User Info fields with one of the following AID12 subfield settings:
  • The AID12 subfield is equal to the 12 LSBs of the AID of the STA when the User Info field is addressed to a STA that is associated with the AP.
  • The AID12 subfield is 0 when the User Info field is addressed to STAs that are associated with the AP and that follow the UL OFDMA-based random access procedure described in 27.5.5 (UL OFDMA-based random access (UORA)).
  • The AID12 subfield is set to 2045 when the User Info field is addressed to STAs that are not associated with the AP and that follow the UL OFDMA-based random access procedure described in 27.5.5 (UL OFDMA-based random access (UORA)).

— Including in the PPDU one or more individually addressed frames that include a UMRS Control subfield and that:
  • Are carried in an S-MPDU format that solicits an immediate Ack frame (see 10.13.8 (Transport of S-MPDUs))
  • Are carried in an A-MPDU format that solicits an immediate BlockAck frame (see 10.24.7.7 (Originator's behavior))
  • Are carried in a multi-TID A-MPDU format that solicits an immediate Multi-STA BlockAck frame (see 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU))

NOTE—The AP additionally follows the rules defined in 27.3.2 (Dynamic fragmentation) when fragments are present in the generated MPDU(s).

More than one Trigger frame may be aggregated in an A-MPDU. If more than one Trigger frame is aggregated in an A-MPDU, all of them shall have the same content.

NOTE—The UMRS Control fields within MPDUs carried in an A-MPDU have the same value (see 10.9 (HT Control field operation)).

The following two frames shall not be present in the same A-MPDU:

— A Trigger frame with a User Info field addressed to a STA
— An MPDU that contains an UMRS Control subfield and that is addressed to the same STA

When one or more Trigger Frames are aggregated with other frames in an A-MPDU, the following ordering rules apply:

— When an Ack, BlockAck or Multi-STA BlockAck frame is not present in the A-MPDU, a Trigger frame shall be the first MPDU in the A-MPDU
— When an Ack, BlockAck or Multi-STA BlockAck frame is present in the A-MPDU, the Ack, BlockAck or Multi-STA BlockAck frame shall be the first MPDU in the A-MPDU and a Trigger frame shall follow the Ack, BlockAck or Multi-STA BlockAck frame

A non-AP STA shall not send a Trigger frame or a frame with a UMRS Control field.

An AP operating in an operating class for which the behavior limits set listed in Annex E includes the DFS_50_100_Behavior shall not transmit a Trigger frame that contains at least one User Info field whose RU Allocation subfield indicates a 26-tone RU or a frame with a UMRS Control field whose RU Allocation subfield indicates a 26-tone RU if the AP has received at least one Beacon frame or Probe Response frame in which any of the following are true:

— The Extended Capabilities element is not present.
— The OBSS Narrow Bandwidth RU in UL OFDMA Tolerance Support bit in the Extended Capabilities element is not present.

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— The OBSS Narrow Bandwidth RU in UL OFDMA Tolerance Support bit in the Extended Capabilities element is 0.

NOTE—If a non-AP HE STA does not respond to a Trigger frame or a frame with a UMRS Control field in which the STA was allocated a 26-tone RU when operating in an operating class for which the behavior limits set listed in Annex E includes the DFS_50_100_Behavior, then the AP is recommended not to allocate 26-tone RU for the same non-AP HE STA in the next Trigger frame or frame with a UMRS Control field.

27.5.3.2.2 Padding for Trigger frame or frame containing UMRS Control field

An AP transmitting a PPDU that contains a Trigger frame or frame containing a UMRS Control field shall ensure that the duration of the PPDU that follows B_{SYM} is greater than or equal to the time indicated by the non-AP STA in the Trigger Frame MAC Padding Duration subfield in the HE MAC Capabilities Information field of the HE Capabilities element that it transmits. B_{SYM} is the OFDM symbol of the PPDU that contains either the last bit of *SCH* when BCC is used to encode the PSDU or the last coded bit of the LDPC codeword that encodes the last bit of *SCH* when LDPC is used to encode the PSDU, where *SCH* is either:

- The User Info field addressed to the STA of the last (or only) Trigger frame, or
- The UMRS Control subfield of the last (or only) frame.

An AP transmitting a Trigger frame that contains a User Info field for random access shall ensure that a *MinTrigProcTime* corresponding to at least the largest value amongst all associated STAs passes from the last User Info field with AID12 subfield equal to 0. An AP transmitting a Trigger frame that contains a User Info field for random access should ensure that a *MinTrigProcTime* of at least 16 μs passes from the last User Info field with AID12 subfield equal to 2045.

An HE AP may use any type of MAC padding to ensure that the *MinTrigProcTime* passes, such as using the Padding field in a Trigger frame, post-EOF A-MPDU padding or aggregating other MPDUs in the A-MPDU. An AP that intends to use Padding field in a Trigger frame shall indicate the start of Padding field by assigning a value of 4095 to the AID12 subfield of a User Info field that would otherwise be present and shall set the subsequent bits of the Padding field to all 1s.

27.5.3.2.3 Allowed settings of the Trigger frame fields and UMRS Control field

An HE AP shall not send a Trigger frame with User Info fields addressed to STAs from two or more BSSs of a multiple BSSID set to a STA unless the STA has set the Rx Control Frame To MultiBSS subfield in the HE MAC Capabilities Information field of the HE Capabilities element it transmits to 1.

An AP that transmits a Trigger frame shall set the TA field of the frame to the MAC address of the AP, except when dot11MultiBSSIDActivated is true and the Trigger frame is directed to STAs from at least two different BSSs of a multiple BSSID set, in which case, the AP shall set the TA field of the frame to the transmitted BSSID.

An AP shall not set any subfields of the Common Info field of a Trigger frame to a value that is not supported by all the recipient STAs of the Trigger frame.

An AP shall set all the subfields, except the Trigger Type subfield, of the Common Info field of a Trigger frame to the same value of the corresponding subfield of the Common Info field of any other Trigger frame that is carried in the same PPDU. An AP shall set the HE TB PPDU Length and DL Tx Power subfields of an UMRS Control field to the same value of the corresponding subfield of any UMRS Control field that is carried in the same PPDU. An AP shall set the following subfields of the Common Info field of a Trigger frame accordingly if an UMRS Control field is carried in an MPDU within the same PPDU:

— MU-MIMO LTF Mode and STBC fields are set to 0

— Number Of HE-LTF Symbols field is set to 0

— Spatial Reuse is set to SRP_AND_NONSRG_OBSS-PD_PROHIBITED

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— GI and LTF Type is set to 2 if the carrying PPDU TXVECTOR parameter HE_LTF_TYPE is 4x LTF for 3.2 μs or 2x LTF for 1.6 μs; otherwise is set to 1

— CS Required subfield is set to 0

NOTE—STAs obtain the common information explicitly, implicitly or both. Explicit information is obtained in the Common Info field of a Trigger frame, or in the HE TB PPDU Length and DL TX Power subfields of the UMRS Control field contained in the soliciting PPDU. Implicit information is obtained in previously exchanged frames with the AP, e.g., in the BSS Color and the Default PE Duration subfields of the HE Operation element, or from default values specified in 27.5.3.3 (STA behavior for UL MU operation).

An AP shall not set any subfields of the User Info field of a Trigger frame to a value that is not supported by the recipient STAs of the User Info field. An AP shall not set any subfields of a UMRS Control field in an HE variant HT Control field to a value that is not supported by the recipient STAs of the UMRS Control field. When an RU is allocated to only one STA the Starting Spatial Stream subfield for that STA shall be set to 0.

If a Trigger frame is transmitted in an RU of an HE MU PPDU and the RU is addressed to multiple STAs, then the Trigger frame shall not include any User Info fields addressed to a STA that is identified as recipient of another RU or spatial stream of the same HE MU PPDU.

A UMRS Control field shall not be included in a group addressed MPDU.

If an AP transmits one or more Trigger frames or frames carrying a UMRS Control field, then the frames shall collectively elicit HE TB PPDU responses such that at least one scheduled RU is allocated for each 20 MHz channel occupied by the eliciting PPDU. An AP shall not allocate an RU in any 20 MHz channel that is not occupied by the immediately preceding DL PPDU. An AP may indicate an unassigned RU by using value 2046 in the AID12 subfield. A Trigger frame shall not contain more than one User Info field with the same value in the AID12 subfield except when the value of the AID12 subfield is 0, or greater than 2007.When a Trigger frame contains User Info fields with the same value in the AID12 subfield, they shall appear in a contiguous block. When a Trigger frame contains User Info fields with AID12 subfield equal to 0 or greater than 2007, they shall appear after User Info fields with values of AID12 subfield greater than 0 and less than 2008 (if any present). When a unicast Trigger frame contains one User Info field, the AID12 subfield of the User Info field shall be set to the 12 LSBs of the AID of the non-AP STA whose MAC address is set in the RA field of the frame.

The AP shall set the value in the TID Aggregation Limit subfield in the Trigger Dependent User Info field to 0 or 1 for an HE STA that has 0 in the Multi-TID Aggregation Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element it transmits and is identified by the AID12 subfield of the User Info field of a Basic Trigger frame (see 9.3.1.23 (Trigger frame format)). A value 0 in the TID Aggregation Limit subfield indicates to the STA that it shall not solicit any immediate response for the MPDUs that the STA aggregates in the HE TB PPDU. A value greater than 0 in the TID Aggregation Limit subfield-indicates the number of TIDs that the STA can aggregate in the A-MPDU carried in the HE TB PPDU (see 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU)).

An AP that sends a Basic Trigger frame may set the TID Aggregation Limit subfield of a User Info field that is intended to a non-AP STA to any value between 0 and the most recently received Multi-TID Aggregation Support subfield of an HE Capabilities element sent by the STA. A value of 7 in the TID Aggregation Limit subfield indicates to the STA that it may aggregate QoS Data frames from any number of different TID values in the multi-TID A-MPDU.

The AP may assign any value defined in Table 9-25j (Preferred AC subfield encoding) in the Preferred AC subfield in the Trigger Dependent User Info field for an HE STA and identified by the AID12 subfield of the User Info field of a Basic Trigger frame. If the AP does not have a recommendation then it shall set the Preferred AC subfield to a value 0.

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An HE AP shall not use the short guard interval for an HT or VHT PPDU that carries a Trigger frame. A Trigger frame shall not be carried in a DSSS or HR/DSSS PPDU. An HE AP shall not use STBC encoding for a PPDU that carries a Trigger frame.

27.5.3.2.4 AP access procedures for UL MU operation

When an AP receives an immediate response with at least one MPDU from at least one STA solicited by a Trigger frame or UMRS Control field, the procedures described in 10.22.2.7 (Multiple frame transmission in an EDCA TXOP) apply.

When an AP does not receive an immediate response with at least one MPDU from at least one STA solicited by a PPDU that contains at least one Trigger frame the backoff procedure described in 10.22.2.2 (EDCA backoff procedure) applies.

An AP may use any AC for sending a PPDU that contains only Trigger frames. If the PPDU contains frames that are not Trigger frames in addition to a Trigger frame, then the AP shall access the medium using the primary AC as defined in 10.22.2.6 (Sharing an EDCA TXOP).

27.5.3.3 STA behavior for UL MU operation

A STA shall not send an HE TB PPDU unless it is explicitly triggered by an AP in one of the operation modes described in this subclause.

The inter-frame space between a PPDU that contains a Trigger frame or frame that includes a UMRS Control subfield that solicits an immediate response and the HE TB PPDU is SIFS.

A non-AP HE STA operating in an operating class for which the behavior limits set listed in Annex E includes the DFS_50_100_Behavior shall not transmit an HE TB PPDU in response a Trigger frame or a frame with a UMRS Control field that is intended to the STA or is designated for UL OFDMA-based random access if the RU Allocation subfield allocated to the STA or designated for UL OFDMA-based random access indicates 26-tone RU and the non-AP HE STA has received at least one Beacon frame or Probe Response frame in which any of the following are true:

— The Extended Capabilities element is not present.

— The OBSS Narrow Bandwidth RU in UL OFDMA Tolerance Support bit in the Extended Capabilities element is not present.

— The value of the OBSS Narrow Bandwidth RU in UL OFDMA Tolerance Support bit in the Extended Capabilities element is 0.

A non-AP HE STA may ignore a Trigger frame that contains one or more subfields in either the Common Info field or the User Info field addressed to the STA with values are not recognized or not supported by the STA. A non-AP HE STA may ignore a UMRS Control field in a frame addressed to the STA if the UMRS Control field contains one or more subfields with values that are not recognized or not supported by the STA. A non-AP STA shall update the intra-BSS NAV (see 27.2.4 (Updating two NAVs)) based on the duration information of the Trigger frame or frame containing UMRS Control field even if it decides to ignore its content.

A STA shall commence the transmission of an HE TB PPDU at the SIFS time boundary after the end of a received PPDU, when the following conditions are met:

— The received PPDU contains either a Trigger frame (that is not an MU-RTS variant) with a User Info field addressed to the STA, or an MPDU addressed to the STA that contains an UMRS Control field. The User Info field in the Trigger frame is addressed to a STA if one of the following conditions are met:

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- The AID12 subfield is equal to the 12 LSBs of the AID of the STA and the STA is associated with the AP
- The AID12 subfield is 0, the STA supports the UL OFDMA-based random access procedure (see 27.5.5 (UL OFDMA-based random access (UORA))) and the STA is associated with the AP
- The AID12 subfield is 2045, the STA supports the UL OFDMA-based random access procedure (see 27.5.5 (UL OFDMA-based random access (UORA))), and the STA is not associated with the AP.

— The CS Required subfield in the Trigger frame is 1 and the UL MU CS condition described in 27.5.3.5 (UL MU CS mechanism) indicates the medium is idle, or the CS Required subfield in a Trigger frame is 0.

If the either condition is not met, then the STA shall not send an HE TB PPDU.

A STA addressed by a User Info field in a Trigger frame (i.e., the AID12 subfield is equal to the 12 LSBs of the AID of the STA) may ignore the remainder of User Info fields in the Trigger frame.

A non-AP HE STA transmitting an HE TB PPDU in response to a Trigger frame shall set the TXVECTOR parameters as follows:

— The FORMAT parameter is set to HE_TRIG

— The TRIGGER_METHOD parameter is set to TRIGGER_FRAME

— The TXOP_DURATION parameter is set as defined in 27.11.5 (TXOP_DURATION)

— The BSS_COLOR parameter is set as follows:

- If the Trigger frame was received in an HE PPDU, then set to the value of the RXVECTOR parameter BSS_COLOR of the HE PPDU
- If the Trigger frame was received in a non-HE PPDU, then set to the value of the BSS Color subfield of the most recently received HE Operation element for the BSS with which the STA is associated

— The L_LENGTH parameter is set to the value indicated by the Length subfield in the Common Info field of the Trigger frame

— The GI_TYPE and HE_LTF_TYPE parameters are set to the value indicated by the GI and LTF Type subfield of the Common Info field of the Trigger frame

— The NUM_STS parameter is set to the number of space-time streams indicated by the Number Of Spatial Streams subfield of the SS Allocation field of the User Info field and STBC field in the Common Info field of the Trigger frame

— The CH_BANDWIDTH parameter is set to the value of the BW field in the Common Info field of the Trigger frame

— The HE_LTF_MODE parameter is set to the value indicated by the MU-MIMO LTF Mode subfield of the Common Info field of the Trigger frame

— The NUM_HE_LTF parameter is set to the value indicated by the Number Of HE-LTF Symbols subfield of the Common Info field of the Trigger frame

— The STBC parameter is set to the value indicated by the STBC subfield of the Common Info field of the Trigger frame

— The LDPC_EXTRA_SYMBOL parameter is set to the value indicated by the LDPC Extra Symbol Segment subfield of the Common Info field of the Trigger frame

— The SPATIAL_REUSE parameter is set to the value of the Spatial Reuse subfield in the Common Info field of the eliciting Trigger frame

— The HE_SIGA_RESERVED parameter is set to the value of the HE-SIG-A Reserved subfield in the Common Info field of the Trigger frame

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- The MCS parameter is set to the value of the MCS subfield in the User Info field of the Trigger frame
- The DCM parameter is set to the value indicated by the DCM subfield of the User Info field of the Trigger frame
- The STARTING_STS_NUM parameter is set to the value of the Starting Spatial Stream subfield in the SS Allocation field in the User Info field of the Trigger frame
- The FEC_CODING parameter is set to the value indicated by the Coding Type subfield of the User Info field of the Trigger frame
- The RU_ALLOCATION parameter is set to the value indicated by the RU Allocation subfield of the User Info subfield of the Trigger frame
- The TXPWR_LEVEL_INDEX parameter is set to a value based on the Transmit Power Control for HE TB PPDU and based on the value of the AP Tx Power subfield in the Common Info field and the Target RSSI subfield in the User Info field of the Trigger frame (see 28.3.14.2 (Power pre-correction)).

NOTE—It is not always possible to fragment HE compressed beamforming feedback (see 27.6.4 (Rules for generating segmented feedback)). If the length is insufficient to contain the HE compressed beamforming feedback requested by a BRP Trigger frame, no feedback is sent.

A STA transmitting an HE TB PPDU in response to a frame containing a UMRS Control field shall set the TXVECTOR parameters as follows:

- The FORMAT parameter is set to HE_TRIG
- The TRIGGER_METHOD parameter is set to UMRS
- The L_LENGTH parameter is set based on N_{SYM}, which is set to F_{VAL} + 1, where F_{VAL} is the value of the HE TB PPDU Length subfield of the UMRS Control subfield
- The RU_ALLOCATION and MCS parameters are set to the values of the RU Allocation and UL MCS subfields of the UMRS Control subfield, respectively.
- The CH_BANDWITDTH parameter is set to the value of the RXVECTOR parameter CH_BANDWIDTH of the soliciting DL MU PPDU
- The BSS_COLOR and DCM parameters are set to the values of the RXVECTOR parameters BSS_COLOR and DCM of the soliciting DL MU PPDU, respectively
- The HE_LTF_MODE, STBC, and NUM_STS parameters are set to 0
- The CODING_TYPE parameter is set to 0 if the RU Allocation subfield indicates less than 484-tone RU; otherwise set to 1
- The LDPC_EXTRA_SYMBOL parameter is not present if the RU Allocation subfield indicates less than a 484-tone RU; otherwise set to 1
- The SPATIAL_REUSE parameter is set to SRP_AND_NONSRG_OBSS-PD_PROHIBITED
- The DEFAULT_PE_DURATION parameter is set to the default PE duration value for UL MU response scheduling, which is indicated by the AP in the Default PE Duration subfield of the HE Operation element it transmits and the pre-FEC padding factor is set to 4 (see 28.3.12 (Packet extension))
- The TXOP_DURATION parameter is set as defined in 27.11.5 (TXOP_DURATION)
- The HE_SIGA_RESERVED parameter is set to 511 (all 1s)
- The HE_LTF_TYPE and GI_TYPE parameters are set to 4x HE-LTF and 3.2 μs, respectively, if the RXVECTOR parameters HE_LTF_TYPE and GI_TYPE of HE MU PPDU containing the frame carrying the UMRS Control field are either 4x LTF and 3.2 μs or 2x LTF and 1.6 μs, respectively. Otherwise, the HE_LTF_TYPE and GI_TYPE parameters are set to 2x LTF and 1.6 μs, respectively.

NOTE 1—Both physical CS and virtual CS are ignored when transmitting an HE TB PPDU as CS required is 0 or is assumed to be 0 (see 27.5.3.5 (UL MU CS mechanism)).

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The RA field of the frames sent in response to a MU-RTS Trigger frame is set as defined in 9.3.1.3 (CTS frame format). The RA field of the MPDUs sent in response of a GCR MU-BAR Trigger frame or MU-BAR Trigger frame is set as defined in 9.3.1.9 (BlockAck frame format). BlockAck frame and Data frames whose RAs are different shall not be aggregated in one A-MPDU in responding to a GCR MU-BAR Trigger frame or MU-BAR Trigger frame. The RA field of the Data frames and Management frames sent in response to a Trigger frame shall be set to the MAC address of the destination AP.

NOTE—All MPDUs within an A-MPDU carried in an HE TB PPDU have the same RA (see 9.7.3 (A-MPDU contents)). The settings of the address fields of MPDUs within the A-MPDU depend on the type and subtype of the MPDU as defined in 9.3 (Format of individual frame types).

A STA generates the A-MPDU carried in the HE TB PPDU as defined in 27.5.3.4 (A-MPDU contents in an HE TB PPDU).

27.5.3.4 A-MPDU contents in an HE TB PPDU

A STA that is the intended receiver of a Trigger frame or of an MPDU that includes an UMRS Control field shall follow MAC padding procedure described in 27.10.3 (A-MPDU padding for an HE TB PPDU) and construct the A-MPDU carried in the response HE TB PPDU as described below.

NOTE—The MU RTS Trigger frame and the NFRP Trigger frame are exempt from these construction rules since the MU RTS Trigger frame does not solicit an HE TB PPDU and the NFRP Trigger frame solicits an HE TB PPDU that does not carry an A-MPDU.

A STA transmitting an HE TB PPDU follows the rules in 27.10.3 (A-MPDU padding for an HE TB PPDU) for constructing the PSDU carried in the HE TB PPDU.

A STA that responds to a DL MU PPDU containing MPDU(s) addressed to it that include UMRS Control field(s) follows the rules defined in 10.3.2.9 (Ack procedure) for generating the Ack frame, the rules defined in 10.24.7.5 (Generation and transmission of BlockAck frames by an HT STA or DMG STA) for generating the BlockAck frame, and the rules defined in 27.4 (HE block acknowledgement procedure) for generating the Multi-STA BlockAck frame if at least one of the received MPDUs solicits an immediate acknowledgment. The contents of the A-MPDU carried in the HE TB PPDU shall be as defined in:

— Table 9-428 (A-MPDU contents MPDUs in the control response context) when at least one of the received MPDUs solicits an immediate acknowledgement. The STA may aggregate any type of Action No Ack frame in the A-MPDU.

— Table 9-426 (A-MPDU contents in the data enabled no immediate response context) when none of the received MPDUs solicit an immediate acknowledgement. The STA shall not aggregate QoS Data frames.

NOTE 1—The STA additionally follows the rules defined in 27.3.2 (Dynamic fragmentation) when fragments are present in the soliciting (A-)MPDU(s).

NOTE 2—The responding STA would be an unassociated STA when the MPDUs are contained in an RU identified by STA-ID equal to 2045.

A STA that responds to a Basic Trigger frame addressed to it shall construct the A-MPDU carried in the HE TB PPDU as defined in:

— Table 9-428 (A-MPDU contents MPDUs in the control response context) when the TID Aggregation Limit field of the User Info field addressed to the STA is 0, the Trigger frame is contained in an A-MPDU, and the STA receives at least another MPDU that solicits an immediate acknowledgment. The A-MPDU shall contain at least the solicited control response and may contain the other MPDUs listed in the table.

— Table 9-426 (A-MPDU contents in the data enabled no immediate response context) when the TID Aggregation Limit field of the User Info field addressed to the STA is 0 and the Trigger frame is

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either not contained in an A-MPDU or is contained in an A-MPDU but the STA receives no other MPDUs that solicit an immediate acknowledgment.

— Table 9-429 (A-MPDU contents in the S-MPDU context) when the TID Aggregation Limit field of the User Info field addressed to the STA is greater than 0 and the STA intends to carry only one MPDU in the A-MPDU, where the MPDU is preceded by a nonzero length MPDU delimiter with EOF equal to 1. The A-MPDU may contain any of the MPDUs listed in the table with the following restrictions:
  - Shall contain the control response frame if the STA received at least another MPDU that solicits an immediate acknowledgment.
  - If the MPDU is a Multi-TID BAR frame then the number of TIDs present in the frame shall not exceed the TID aggregation limit

— Table 9-425 (A-MPDU contents in the data enabled immediate response context) when the TID Aggregation Limit field of the User Info field addressed to the STA is greater than 0 and the STA intends to carry one or more MPDUs, each preceded by nonzero length MPDU delimiter with EOF equal to 0 (see 10.13 (A-MPDU operation)) and 27.10.4.2 (Non-ack enabled multi-TID A-MPDU operation)). The A-MPDU may contain any of the MPDUs listed in the table with the following restrictions:
  - Shall contain the control response frame if the STA received at least another MPDU that solicits an immediate acknowledgment.
  - The number of TIDs present in the A-MPDU shall count towards reaching the TID aggregation limit.

— Table 9-425 (A-MPDU contents in the data enabled immediate response context) when the TID Aggregation Limit field of the User Info field addressed to the STA is greater than 0 and the STA intends to carry an ack-enabled A-MPDU (see 27.10.4.1 (General) and 27.10.4.3 (Ack-enabled multi-TID A-MPDU operation). The A-MPDU may contain any of the MPDUs listed in the table with the following exceptions:
  - Shall contain the control response frame if the STA receives at least another MPDU that solicits an immediate acknowledgment.
  - The number of TIDs present in the A-MPDU, in either QoS Data or BlockAckReq frames, shall count towards reaching the TID aggregation limit

A STA that responds to a BRP Trigger frame addressed to it shall construct the A-MPDU carried in the HE TB PPDU as defined in Table 9-428 (A-MPDU contents MPDUs in the control response context), except that only Compressed Beamforming And CQI frames shall be allowed in the A-MPDU; other frames shall not be allowed in the A-MPDU. The STA includes at least one Compressed Beamforming And CQI frame in the A-MPDU as defined in 27.6 (HE sounding protocol).

A STA that responds to an MU BAR Trigger frame addressed to it shall construct the A-MPDU carried in the HE TB PPDU as defined in Table 9-428 (A-MPDU contents MPDUs in the control response context). The STA includes either a BlockAck frame or a Multi-STA BlockAck frame in the A-MPDU as defined in 27.4 (HE block acknowledgement procedure).

A STA that responds to a GCR MU BAR Trigger frame addressed to it shall construct the A-MPDU carried in the HE TB PPDU as defined in Table 9-428 (A-MPDU contents MPDUs in the control response context). The STA includes a GCR BlockAck frame in the A-MPDU as defined in 10.24.10 (GCR and GLK-GCR block ack).

A STA that responds to a BSRP or BQRP Trigger frame addressed to it shall construct the A-MPDU carried in the HE TB PPDU as defined in Table 9-426 (A-MPDU contents in the data enabled no immediate response context). The STA shall include in the A-MPDU at least one QoS Null frame.

NOTE 1—An AP can include other MPDUs in a soliciting DL MU PPDU that contains Trigger frames as specified in 9.7.3 (A-MPDU contents).

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NOTE 2—The frame type of MPDUs may be different across A-MPDUs within the same HE TB PPDU.

NOTE 3—A STA follows the rules in 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU) for aggregating the QoS Data frames with multiple TIDs in HE TB PPDUs.

A STA that is scheduled in a Trigger frame or is the intended receiver of an UMRS Control field transmits the dB value of its UL power headroom, HR_{STA}, in the HE TB PPDU sent in response to assist in the AP's MCS selection. The UL power headroom for the assigned MCS is defined in Equation (27-1).

$$HR_{STA} = Tx_{pwr}^{Max} - Tx_{pwr}^{STA} \quad (27\text{-}1)$$

where

Tx_{pwr}^{Max} represents the maximum UL transmit power of an HE TB PPDU with the assigned MCS

Tx_{pwr}^{STA} represents the current UL transmit power of the HE TB PPDU for the assigned MCS

HR_{STA} is the UL headroom, in dB, of the HE TB PPDU, the encoding of which is specified in 9.2.4.6.4.6 (UPH Control).

NOTE—If the Minimum Transmit Power Flag subfield in the UPH Control field is 1, then the STA is transmitting the HE TB PPDU at its minimum Tx_{pwr}^{STA} for the assigned MCS.

The STA shall include an HE Control field containing the UPH Control field in MPDUs carried in the A-MPDU of the HE TB PPDU except when:

— The remaining space in the A-MPDU, after inclusion of solicited MPDUs that cannot contain an HE Control field, is not sufficient to contain MPDU(s) that contain an HE Control field

— The STA includes other Control fields in the HE Control field and the available space in the HE Control field is not sufficient to contain an additional UPH Control field.

27.5.3.5 UL MU CS mechanism

The ED-based CCA and virtual CS functions are used to determine the state of the medium if CS is required before responding to a received Trigger frame. ED-based CCA for the UL MU CS mechanism is defined in 28.3.19.6.2 (CCA sensitivity for operating classes requiring CCA-ED) and virtual CS is defined in 10.3.2.1 (CS mechanism).

If the CS Required subfield in a received Trigger frame is 0 or a frame that includes a UMRS Control field and solicits a response is received, then the STA may respond without regard to the busy/idle state of the medium.

NOTE—Responding without regard to the busy/idle state of the medium means that a STA can respond without the need to check the medium indication from physical CS and virtual CS (i.e., basic NAV and Intra-BSS NAV).

A NAV is considered in virtual CS for a STA that responds to a Trigger frame from an associated AP unless one of the following conditions is met:

— The NAV was set by an intra-BSS frame

— The NAV counter is 0

A NAV is considered in virtual CS for a STA that responds to a Trigger frame from an unassociated AP through the UORA procedure (see 27.5.5 (UL OFDMA-based random access (UORA))) unless one of the following conditions is met:

— The NAV was set by a frame originating from the AP sending the Trigger frame

— The NAV counter is 0

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NOTE 1—The details of how a STA is solicited by the Trigger frame for transmission are described in 27.5.3.2.3 (Allowed settings of the Trigger frame fields and UMRS Control field).

NOTE 2—When a STA responds to a Trigger frame from an unassociated AP through the UORA procedure, the method to identify that a NAV was set by a frame originating from the STA sending the Trigger frame is implementation specific. For example, a STA can save the TXOP holder address and match the saved TXOP holder address with the TA field of the Trigger frame.

For a STA that is solicited by a Trigger frame for transmission, the indication of the virtual CS is described as follows. If no NAV is considered, then the virtual CS indicates idle. Otherwise, the virtual CS indicates busy.

If the CS Required subfield in a Trigger frame is set to 1, the STA shall consider the status of the CCA (using Energy Detect defined in 28.3.19.6.5 (Per 20 MHz CCA sensitivity) and the virtual carrier sense (NAV) during the SIFS between the Trigger frame and the PPDU sent in response to the Trigger frame. In this case, the STA shall sense the medium using energy-detect (ED) after receiving the PPDU that contains the Trigger frame (i.e. during the SIFS time), and it shall perform the energy-detect (ED) at least in the subchannel that contains the STA's UL allocation, where the sensed subchannel consists of one or more 20 MHz channels. The STA may transmit the solicited PPDU when the 20 MHz channels containing the RUs allocated in the Trigger frame are considered idle. If the STA detects that the 20 MHz channels containing the allocated RUs are not all idle, then the STA shall not transmit.

NOTE—The solicited PPDU is a non-HT or non-HT duplicate PPDU if the Trigger frame is an MU-RTS Trigger frame (see 27.2.5 (MU-RTS/CTS procedure)); otherwise, the solicited PPDU is an HE TB PPDU (see 27.5.3.3 (STA behavior for UL MU operation)).

The CS Required subfield in the MU-RTS Trigger frame and BQRP Trigger frame shall be set to 1.

The AP shall set the CS Required subfield to 1 except when one of the following conditions is met:

— The RA of the Trigger frame is an individually addressed STA's MAC address and a QoS Data frame with Ack Policy set to HE TB PPDU (HTP) Ack is aggregated with the Trigger frame in an A-MPDU, and the Length subfield in the Common Info field of the Trigger frame is less than or equal to 418.

— The Trigger Type of the Trigger frame is either MU-BAR or GCR MU-BAR, and the Length subfield in the Common Info field of the Trigger frame is less than or equal to 418.

NOTE—The threshold value 418 of the Length subfield in the Common Info field of the Trigger frame is obtained from the maximum HE TB PPDU duration, 584 μs, that can be solicited by the UMRS Control field based on Equation (28-16). This duration is the sum of 20 μs for the L-STF, L-LTF and L-SIG fields, 20 μs for the RL-SIG, HE-SIG-A and HE-STF fields, 16 μs for the 4x HE-LTF field with 3.2 μs GI, 512 μs for 32 OFDM symbols in the Data field with 3.2 μs GI, and 16 μs PE field (see 9.2.4.6.4.2 (UMRS Control), 27.5.3.3 (STA behavior for UL MU operation), and 28.3.4 (HE PPDU formats)).

27.5.3.6 HE buffer status feedback operation for UL MU

A non-AP STA delivers buffer status reports (BSRs) to assist its AP in allocating UL MU resources. The non-AP STA can either implicitly deliver BSRs in the QoS Control field or BSR Control field of any frame transmitted to the AP (unsolicited BSR) or explicitly deliver BSRs in any frame sent to the AP in response to a BSRP Trigger frame (solicited BSR).

A non-AP STA reports its buffer status (unsolicited BSR) to the AP to which it is associated using either the QoS Control field or the BSR Control field of frames it transmits as defined below:

— The HE STA shall report the buffer status for a given TID in the Queue Size subfield of the QoS Control field in QoS Data or QoS Null frames it transmits; except that the STA may set the Queue Size subfield to 255 to indicate an unknown/unspecified BSR for that TID.

  • The HE STA may aggregate multiple QoS Data frames or QoS Null frames in an A-MPDU to report the buffer status for different TIDs. The HE STA shall follow the A-MPDU aggregation

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rules defined in 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU) for aggregating QoS Data frames with multiple TIDs. The HE STA does not follow the rules defined in 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU) for QoS Null frames whose Ack Policy subfield is No Ack.

— The HE STA may report the buffer status in the BSR Control field of frames it transmits if the AP has indicated its support in the BSR Support subfield of its HE Capabilities element; otherwise the STA shall not report the buffer status in the BSR Control field.

  - The HE STA shall report the buffer status for its preferred AC, indicated by the ACI High subfield, in the Queue Size High subfield of the BSR Control field; except that the STA may set the Queue Size High subfield to 255 to indicate an unknown/unspecified BSR for that AC
  - The HE STA shall report the buffer status for all ACs, indicated by the ACI Bitmap subfield, in the Queue Size All subfield of the BSR Control field; except that the STA may set the Queue Size All subfield to 255 to indicate an unknown/unspecified BSR for those ACs
  - The HE STA shall set the Delta TID subfield according to Table 9-18e (Delta TID subfield encoding), and the Scaling Factor subfield as defined in 9.2.4.6.4.5 (BSR Control).

NOTE 1—The STA can send an unsolicited BSR in response certain Trigger frames except MU-RTS and BSRP (with or without random access RUs, as defined in 27.5.3.3 (STA behavior for UL MU operation) and in 27.5.5 (UL OFDMA-based random access (UORA))) or it can send the unsolicited BSR after accessing the WM using EDCA.

NOTE 2—The STA can include both the QoS Control and the BSR Control field in the same frame. In this case it can set the Queue Size subfield of either field to a value of 255 or have both fields carry the same value in the Queue Size subfield.

An AP can also solicit one or more associated non-AP STAs for their BSR(s) by sending a BSRP Trigger frame (see 9.3.1.23 (Trigger frame format)). The non-AP STA responds (solicited BSR) as defined below:

— The STA that receives a BSRP Trigger frame shall follow the rules defined in 27.5.3.3 (STA behavior for UL MU operation) to generate the HE TB PPDU when the Trigger frame contains the 12 LSBs of the STA's AID in any of the User Info fields; otherwise if the STA's buffers are not empty and the STA supports the UL OFDMA-based random access procedure, it may follow the rules defined in 27.5.5 (UL OFDMA-based random access (UORA)) to gain access to a random access RU and generate the HE TB PPDU when the Trigger frame contains one or more random access RUs.

— The STA shall include in the HE TB PPDU one or more QoS Null frames containing one or more of the following:

  - The QoS Control field(s) with Queue Size subfields for each of the TIDs for which the STA has buffer status to report to the AP.
  - The BSR Control field with the Queue Size All subfield indicating the queue size for all the ACs, indicated by the ACI Bitmap subfield, for which the STA has buffer status to report to the AP when the AP has indicated its support in the BSR Support subfield of its HE Capabilities element. The STA shall set Delta TID, SF, ACI High and Queue Size High subfields of the BSR Control field as defined in 9.2.4.6.4.5 (BSR Control).

— The HE STA shall not solicit an immediate response for the frames carried in the HE TB PPDU (e.g., by setting the Ack Policy subfield of the frame to Normal Ack or Implicit Block Ack Request).

NOTE—Similar to unsolicited BSR, the STA can set Queue Sizes in either QoS Control or BSR Control field to 255 to indicate unknown/unspecified BSR for a TID, AC or all AC.

An AP may include a BSRP Trigger frame together with other Control, Data and Management frames in one A-MPDU to a STA if the HE Capabilities element received from the STA has the BSRP A-MPDU Aggregation field equal to 1. If a STA receives a BSRP Trigger frame aggregated with Control, Data and Management frames that solicits an acknowledgement, the response A-MPDU shall contain MPDUs in the order described in Table 9-425 (A-MPDU contents in the data enabled immediate response context).

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27.5.4 MU cascading sequence

If the MU Cascading Support field in the HE MAC Capabilities Information field of the HE Capabilities element is set to 1 by both HE AP and non-AP HE STA(s), an HE AP may initiate an MU cascading sequence in a TXOP, allowing alternating HE MU PPDUs and HE TB PPDUs starting with an HE MU PPDU in the same TXOP, as illustrated in Figure 27-4 (An example of an MU cascading sequence).

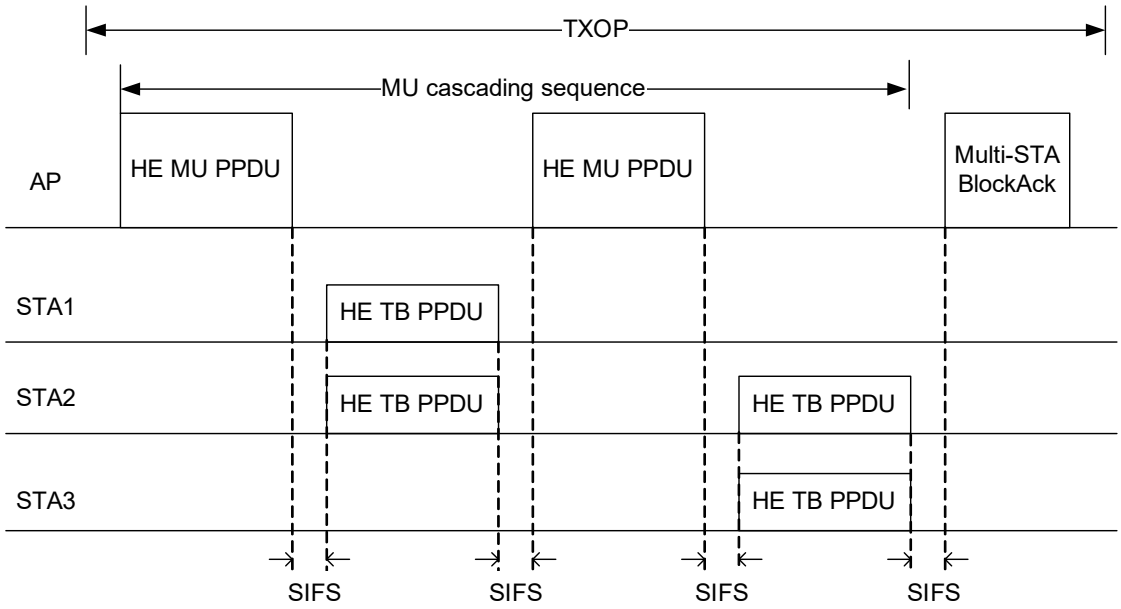


Figure 27-4—An example of an MU cascading sequence

The presence of an HE MU PPDU with the following A-MPDU content may start an MU cascading sequence within that TXOP:

— At most one Ack, BlockAck or Multi-STA BlockAck frame for each of the preceding HE TB PPDUs and,

— Zero or more MPDUs and,

— One or more Trigger frames or frames with a UMRS Control field that allocates an RU for the STA to transmit a subsequent HE TB PPDU if this HE MU PPDU is not the last PPDU of the MU cascading sequence.

An HE TB PPDU in the MU cascading sequence has the following A-MPDU contents:

— At most one Ack or BlockAck frame for the preceding HE MU PPDU and,

— Zero or more MPDUs

If the MU Cascading Support field in the HE MAC Capabilities Information field of the HE Capabilities element is set to 0 by an HE AP, the HE AP shall not initiate an MU cascading sequence in its TXOP(s).

If the MU Cascading Support field in the HE MAC Capabilities Information field of the HE Capabilities element is set to 0 by a non-AP HE STA, the HE AP with which the non-AP HE STA is associated shall not initiate an MU cascading sequence to the non-AP HE STA in its TXOP(s).

The MU cascading sequence may have a different set of transmitters in HE TB PPDUs as compared to the receivers of the HE MU PPDU that immediately follows the HE TB PPDUs within the same TXOP. The

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MU cascading sequence may have a different set of receivers in the HE MU PPDU as compared to the set of transmitters of HE TB PPDUs that immediately follow the HE MU PPDU within the same TXOP.

If an AP does not receive an immediate response from a STA addressed by a Trigger frame or frame carrying a UMRS Control field contained in the HE MU PPDU sent at the beginning of the TXOP, then the AP follows the backoff procedure described in 10.22.2.2 (EDCA backoff procedure).

27.5.5 UL OFDMA-based random access (UORA)

27.5.5.1 General

A STA that supports UORA shall set the UL OFDMA RA Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element to 1. Otherwise, it shall set the UL OFDMA RA Support subfield to 0.

NOTE—STA that does not support UORA can contend for the WM using EDCA for sending UL frames to the AP with which it intends to communicate.

UORA is a mechanism for HE STAs to randomly select resource units (RUs) assigned by an AP in a soliciting Trigger frame that contains RUs for random access.

An eligible random access RU is a random access RU for which the HE STA is capable of generating an HE TB PPDU (i.e., the HE STA supports all transmit parameters indicated in the Common Info field and in the User info field corresponding to the random access RU) and shall satisfy at least one of the following conditions:

— The HE STA is not associated with the BSS it intends to transmit frames to and the AID12 value of the random access RU is 2045

— The HE STA is an associated STA, the TA field of the Trigger frame is set to the BSSID of the associated BSS and the AID12 value of the random access RU is 0

An HE AP may transmit a Basic Trigger frame, BQRP Trigger frame or a BSRP Trigger frame that contains one or more RUs for random access. An HE AP shall not transmit BQRP Trigger frame or BSRP Trigger frame that contains random access RUs for unassociated STAs.

NOTE—Trigger frame variants other than Basic, BQRP or BSRP are not allowed to carry random access RUs.

An HE AP that transmits a Basic Trigger frame should set the TID Aggregation Limit subfield in the User Info field indicating a random access RU to 0 or 1.

The HE AP may include the UORA Parameter Set element (see 9.4.2.239 (UL OFDMA-based Random Access (UORA) Parameter Set element) in Beacon, Probe Response and (Re)Association frames it transmits. The AP shall indicate the range of OFDMA contention window (OCW) in the UORA Parameter Set element for HE STAs to initiate random access following the Trigger frame transmission.

An HE BSS belonging to a Multiple BSSID set (see 11.11.14 (Multiple BSSID set)) may advertise OCW Range values via the UORA Parameter Set element carried in the management frames transmitted by the transmitted BSSID. An HE AP may include the UORA Parameter Set element in a Nontransmitted BSSID profile subelement carried in the Multiple BSSID element (see 9.4.2.46 (Multiple BSSID element)) to provide different OCW Range values for STAs associated with that nontransmitted BSSID.

An HE STA shall obtain OCWmin and OCWmax from the most recently received UORA Parameter Set element (see 9.4.2.239 (UL OFDMA-based Random Access (UORA) Parameter Set element)) carried in the management frames transmitted by its associated AP. A non-AP STA with dot11MultiBSSIDActivated set to true and associated with a nontransmitting BSSID may inherit the OCW Range values from the UORA

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Parameter Set element advertised by the transmitted BSSID if the element is not carried in the Nontransmitted BSSID Profile subelement for that BSSID.

An unassociated HE STA shall initialize the range of OFDMA contention window (OCW) upon reception of the UORA Parameter Set element from the intended HE AP. If the HE STA has not received UORA Parameter Set element from the AP it wishes to communicate with, it shall use the default value OCWmin = 7 and OCWmax = 31 to be used upon reception of a Trigger frame containing RU with an AID12 subfield equal to 0 or 2045. Each time an unassociated HE STA communicates with a different AP using random access it shall initiate its OFDMA random access backoff (OBO) based on the default values or based on the parameters from the received UORA Parameter Set element for that AP.

A non-AP STA with dot11OFDMARandomAccessOptionImlemented set to true shall follow the random access procedure defined in 27.5.5.2 (UORA procedure) to contend for an RU assigned for random access.

27.5.5.2 UORA procedure

In this subclause, the random access procedure is described with respect to UL OFDMA contention parameters. The procedure is also illustrated in Figure 27-5 (Illustration of the UORA procedure).

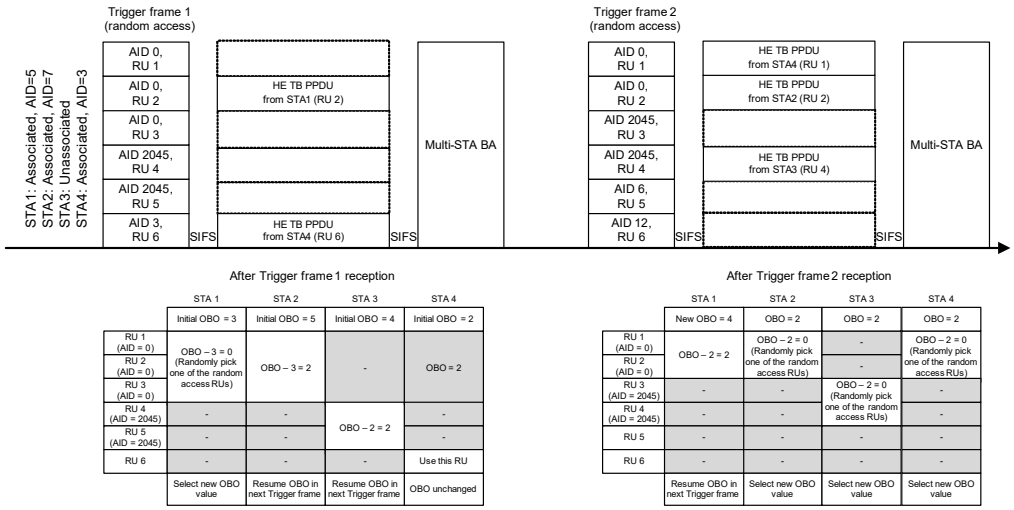


Figure 27-5—Illustration of the UORA procedure

An HE STA shall maintain an internal OFDMA contention window (OCW) and an internal OBO counter. OCW is an integer in the range [OCWmin, OCWmax].

After each successful HE TB PPDU transmission, an HE STA shall set the value of OCW to the OCWmin obtained from the most recent OCWmin indicated in the UORA Parameter Set element from the HE AP and shall initialize its OBO counter to a random integer value in the range of 0 and OCW.

An HE AP that transmits a Trigger frame for random access, uses the AID value 0 to indicate random access RUs allocated for STAs associated with it, and the AID value 2045 to indicate random access RUs allocated for STAs not associated with it.

A STA that is the intended receiver of a User Info field in a Trigger frame (i.e., the AID12 subfield equal to the 12 LSBs of the AID of the STA) shall not contend for a random access RU that is indicated by a Trigger frame contained in the same PPDU and will not decrement its OBO counter.

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A STA shall not contend for an eligible random access RU or decrement its OBO counter if it does not have pending frames for the AP.

For an HE STA that has a pending frame for the AP, upon the reception of a Trigger frame containing at least one eligible random access RU, if the OBO counter of an HE STA is not greater than the number of eligible random access RUs in a Trigger frame from that AP, then the HE STA shall decrement its OBO counter to zero. Otherwise, the HE STA decrements its OBO counter by the number of eligible random access RUs in the Trigger frame.

In the example shown in Figure 27-5 (Illustration of the UORA procedure), HE STA 1 and HE STA 2, both associated with the AP and that has a pending frame for the AP, decrement their nonzero OBO counters by the eligible random access RUs indicated in the Trigger frame where the AID12 subfield is 0. HE STA 3, which is not associated with the AP but has a pending frame for the AP, decrements its nonzero OBO counter by the eligible random access RUs indicated in the Trigger frame where the AID12 subfield is 2045. HE STA 4, which is associated with the AP and has a pending frame for the AP, is assigned RU6 and does not decrement its nonzero OBO counter. HE STA 4 will transmit its pending frame in an HE TB PPDU using the assigned RU6. HE STA 4 still has pending frame for the AP so it maintains OBO counter and resumes random access in next Trigger frame.

A non-AP HE STA can determine the number of eligible random access RUs based on the SS Allocation/ Random Access RU Information subfield belonging to all the User Info fields corresponding to eligible random access RUs. A non-AP HE STA can determine the number of eligible random access RUs by adding the values of the Random Access RU Number subfields plus one belonging to all the User Info fields corresponding to eligible random access RUs. The eligible random access RUs for a non-AP HE STA are the K contiguous RUs starting from the RU indicated in the RU allocation subfield belonging to all the User Info fields corresponding to eligible random access RUs where K equals to the value of the Random Access RU Number subfields plus one.

For an HE STA that has a pending frame for the AP, upon the reception of a Trigger frame containing at least one eligible random access RU, if the OBO counter is 0 or decrements to 0 then the STA randomly selects one of the eligible random access RUs.

If the selected RU is idle as a result of both physical and virtual carrier sensing as defined in subclause 27.5.3.5 (UL MU CS mechanism), the HE STA transmits its HE TB PPDU in the selected RU following the rules of 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU). If the selected RU is considered busy as a result of either physical or virtual carrier sensing, then the HE STA shall not transmit its HE TB PPDU in the selected RU. Instead, the STA shall randomly select its OBO counter in the range of 0 and OCW and if the OBO counter is 0 or the OBO counter decrements to 0, then the STA randomly selects any one of the eligible random access RUs in the subsequent Trigger frame.

If the OBO counter is greater than the number of eligible random access RUs, then the STA resumes with its OBO counter in the next Trigger frame with RUs assigned for random access. In the example shown in Figure 27-5 (Illustration of the UORA procedure), after receiving Trigger frame 1, HE STA 1 transmits an HE TB PPDU because its OBO counter decrements to 0. HE STA 1 then randomly selects RU2 from RU1, RU2, and RU3 which are assigned to AID12 subfield value 0. HE STA 2, HE STA 3, and HE STA 4 hold their OBO counters and wait for the next Trigger frame because their OBO counters don't decrement to 0. On receiving Trigger frame 2, HE STA 2, HE STA 3, and HE STA 4 decrement their OBO counters to 0 and each transmit their pending frame in an HE TB PPDU on a randomly selected RU.

The MU acknowledgment procedure for UORA follows the procedure as defined in 10.3.2.10.3 (Acknowledgement procedure for an UL MU transmission).

If a STA transmits an HE TB PPDU that solicits an immediate response in a random access RU and the expected response is not received, the transmission is considered unsuccessful. Otherwise, the transmission

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is considered successful. The retransmission procedure for UORA is defined in 27.5.5.3 (Retransmission procedure for UORA).

27.5.5.3 Retransmission procedure for UORA

An HE STA whose HE TB PPDU transmission sent in a random access RU of a Trigger frame is unsuccessful, may attempt to retransmit the failed PPDU using EDCA or as a response to a Trigger frame.

If the HE TB PPDU is not successfully transmitted in the selected random access RU, then the STA shall update its OCW to $2 \times \text{OCW} + 1$ when the OCW is less than the value of OCWmax, and shall randomly select its OBO counter in the range of 0 and OCW. Once the OCW reaches OCWmax for successive retransmission attempts, the OCW shall remain at the value of OCWmax until the OCW is reset as described in 27.5.5.2 (UORA procedure).

The transmission of the HE TB PPDU does not affect QSRC[AC] and QLRC[AC] (see 10.22.2.11 (Retransmit procedures)).

27.5.5.4 Acknowledgement for random access

An AP shall respond with a Multi-STA BlockAck Frame in an SU PPDU if the AP receives a Management frame, such as Association Request frame, which is sent by the unassociated non-AP HE STA through OFDMA random access.

27.5.6 NDP feedback report procedure

27.5.6.1 General

The NDP feedback report is a mechanism for an HE AP to collect short feedbacks from multiple HE STAs in a more efficient manner than with the HE TB PPDU. The feedbacks (e.g. resource requests) are sent without data payloads in response to a Trigger frame. The feedbacks are not for channel sounding.

An HE AP sends an NDP Feedback Report Poll Trigger frame to solicit NDP feedback report response from many STAs that are identified by a range of scheduled AIDs in the Trigger frame. The NDP feedback report response from an HE non-AP STA is an HE TB PPDU without data payloads. An HE non-AP STA uses the information carried in the NDP Feedback Report Poll Trigger frame to know if it is scheduled, and in this case, to derive the parameters for the transmission of the response.

In this subclause, the NDP feedback report procedure is described.

27.5.6.2 STA behavior

A STA shall set the NDP Feedback Report Support subfield in the HE Capabilities element to 1 if it supports NDP feedback report and set it 0, otherwise.

A STA shall not transmit an NDP feedback report response unless it is explicitly enabled by an AP in one of the operation modes described in this subclause. The inter frame space between a PPDU that contains an NDP Feedback Report Poll Trigger frame and the NDP feedback report poll response is SIFS. A STA shall commence the transmission of an NDP feedback report response at the SIFS time boundary after the end of a received PPDU, when all the following conditions are met:

— The received PPDU contains an NDP Feedback Report Poll Trigger frame
— The STA is scheduled by the NDP Feedback Report Poll Trigger frame
— The NDP feedback report support subfield in HE MAC Capabilities Information field is set to 1

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— The STA intends to provide a response to the type of the NDP feedback contained in the NDP Feedback Report Poll Trigger frame, as described in 27.5.6.4 (NDP feedback report types).

If a STA does not satisfy all of the above conditions, it is not required to respond to the NDP Feedback Report Poll Trigger frame.

A STA is scheduled to respond to the NDP Feedback Report Poll Trigger frame if its AID is greater than or equal to the starting AID and less than starting AID + N_{STA}, using the Starting AID subfield in the eliciting Trigger frame, and with N_{STA} the total number of STAs that are scheduled to respond to the NDP Feedback Report Poll Trigger frame. N_{STA} is calculated by the following equation, with BW subfield and Multiplexing Flag subfield from the eliciting Trigger frame:

$N_{STA} = 18 \times 2^{BW} \times (\textit{Multiplexing Flag})$

27.5.6.2.1 Transmission of the HE NDP feedback report response

An NDP feedback report response is an HE TB NDP feedback PPDU, as defined in 28.3.17 (HE TB NDP feedback PPDU).

A STA transmitting an NDP feedback report response to a Trigger frame, shall set the TXVECTOR parameter as for transmitting an HE TB PPDU in response to a Trigger frame as described in 27.5.3.3 (STA behavior for UL MU operation), except for the following parameters:

— FORMAT shall be set to HE_TRIG

— PSDU_LENGTH shall be set to 0

— The RU_ALLOCATION parameter shall be set to be maximum RU size for the BW

— The RU_TONE_SET_INDEX parameter shall be set with the following equation, with the value of the Starting AID subfield in the User Info field of the eliciting Trigger frame:

  • RU_TONE_SET_INDEX = (AID − Starting AID) mod (18×2^{BW})

— The NUM_STS parameter shall be set to 1

— The STARTING_STS_NUM parameter shall be set with the following equation, with the values of the Starting AID subfield in the User Info field of the eliciting Trigger frame:

  • STARTING_STS_NUM = $\lfloor$(AID − Starting AID) / 18 / $2^{BW}\rfloor$

— The MCS parameter shall be set to 0

— The DCM parameter shall be set to 0

— The FEC_CODING parameter shall be set to 0

— The TXPWR_LEVEL_INDEX parameter shall be set to the value based on the Transmit Power Control for HE TB PPDU and based on the value of the AP Tx Power subfield and the Target RSSI subfield in the User Info field of the eliciting Trigger Frame (see 28.3.14.2 (Power pre-correction))

A STA transmitting an NDP feedback report response to a Trigger frame shall modulate the assigned tones as descried in 27.5.6.2.2 (Modulation of the assigned tones).

27.5.6.2.2 Modulation of the assigned tones

Each STA that is scheduled for providing a feedback report is assigned a STARTING_STS_NUM and an RU_TONE_SET_INDEX of 12 tones to transmit a bit FEEDBACK_STATUS. Its set of 12 tones is divided into 2 groups of 6 tones, as described in Table 28-28 (HE-LTF tone mapping for the HE TB NDP feedback PPDU):

— If FEEDBACK_STATUS is 1, then the STA shall send energy on the first group of 6 tones and quiet the second group of tones, on its assigned RU_TONE_SET of 12 tones on its assigned RU_allocation.

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— If FEEDBACK_STATUS is 0, then the STA shall send energy on the second group of 6 tones and quiet the first group of tones, on its assigned RU_TONE_SET of 12 tones on its assigned RU_allocation.

27.5.6.3 AP behavior

27.5.6.3.1 Reception of NDP feedback report responses

Following the transmission from an AP of an NDP Feedback Report Poll Trigger frame, multiple STAs may simultaneously send NDP feedback report responses to the AP. Based on the RXVECTOR parameter NDP_REPORT, which provides the detected status array for the resources of each spatial stream and tone set assigned by the Trigger frame, the AP can derive the list of AIDs from the resources of which an NDP feedback report response was sent, and their response.

The AP shall not send any acknowledgement in response to the reception of NDP feedback report responses.

27.5.6.4 NDP feedback report types

27.5.6.4.1 NDP feedback report with resource request type

An HE AP may send an NDP Feedback Report Poll Trigger frame with the type subfield set to "0" for "resource request".

If the Feedback Type subfield in the User Info field of the NDP Feedback Report Poll Trigger frame is set to 0 for "resource request", a STA that is scheduled may send an NDP feedback report response in order to signal to the AP that it has packets in its queues and would like to be triggered in UL MU.

Each STA that is scheduled is assigned an RU_TONE_SET, a STARTING_STS_NUM and an RU_TONE_SET of 12 tones to transmit a FEEDBACK_STATUS bit.

The meaning of the FEEDBACK_STATUS bit is defined in Table 27-1 (FEEDBACK_STATUS description):

Table 27-1—FEEDBACK_STATUS description

FEEDBACK_STATUS	Description
0	Resource request with buffered bytes for transmission between 1 and the resource request buffer threshold.
1	Resource request with buffered bytes for transmission above the resource request buffer threshold.

The resource request buffer threshold is equal to $2^{(\text{Resource request buffer threshold exponent})}$ octets, using the Resource Request Buffer Threshold Exponent subfield in the most recently received NDP Feedback Report Parameter Set element sent by the AP to which the STA is associated. The resource request buffer threshold is equal to 256 octets if no NDP Feedback Report Parameter Set element has been sent by the AP to which the STA is associated.

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27.6 HE sounding protocol

27.6.1 General

Transmit beamforming and DL MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmit signal to optimize reception at one or more receivers. HE STAs use the HE sounding protocol to determine the channel state information. As with the VHT sounding protocol, the HE sounding protocol uses explicit feedback mechanism where the HE beamformee measures the channel using a training signal transmitted by the HE beamformer and sends back a transformed estimate of the channel state. The HE beamformer uses this estimate to derive the steering matrix.

The HE beamformee returns an estimate of the channel state in an HE compressed beamforming feedback. The HE compressed beamforming feedback is an HE Compressed Beamforming Report field for SU-type feedback, the concatenation of an HE Compressed Beamforming Report field and HE MU Exclusive Beamforming Report field for MU-type feedback, and a CQI-only Report field for CQI-type feedback. The HE compressed beamforming feedback is carried in a single HE Compressed Beamforming And CQI Report frame if the resulting frame is less than or equal to 11 454 octets in length. Otherwise, the HE beamforming feedback is segmented and each segment is carried in an HE Compressed Beamforming And CQI Report frame. For CQI-type feedback the HE compressed beamforming feedback is never segmented since the resulting MPDU size will always be less than 11 454 octets.

27.6.2 Sounding sequences and support

An HE STA indicates its role in a sounding sequence, the support of HE sounding sequences, and the supported type of sounding feedback by setting the subfields of the HE Capabilities element it transmits as follows:

— If a STA supports being an SU beamformer then it shall set the SU Beamformer subfield to 1; otherwise, set to 0. A non-AP STA may set the SU Beamformer subfield to 1. An AP that sets the MU Beamformer subfield to 1 shall set the SU Beamformer subfield to 1.

— If a STA supports being an MU beamformer then it shall set the MU Beamformer subfield to 1; otherwise, set to 0. A non-AP STA shall set the MU Beamformer subfield to 0. An AP shall set the MU Beamformer subfield to 1 if it supports transmitting 4 or more spatial streams.

— If a STA supports being an SU beamformee then it shall set the SU Beamformee subfield to 1; otherwise, set to 0. A non-AP STA shall set the SU Beamformee subfield to 1. An AP may set the SU Beamformee subfield to 1.

— A non-AP STA shall support being an MU beamformee. An AP does not support being an MU beamformee.

— An HE STA that is an SU beamformer or an MU beamformer is referred to as an HE beamformer and a STA that is an SU beamformee or an MU beamformee is referred to as an HE beamformee.

— If a STA is an HE beamformee then it shall set the Beamformee STS ≤ 80 MHz and Beamformee STS >80 MHz subfields to the maximum number of space-time streams, $N_{STS,max}$, minus one supported when receiving an HE NDP in channel widths less than or equal to 80 MHz and greater than 80 MHz, respectively; otherwise, set to 0. An HE beamformee shall support an $N_{STS,\ max}$ of at least 4 for ≤ 80 MHz, and an $N_{STS,\ max}$ at least 4 for > 80 MHz when indicating channel widths greater than 80 MHz in the Channel Width Set subfield.

— If a STA is an HE beamformer then it shall set the Number Of Sounding Dimensions ≤ 80 MHz and Number Of Sounding Dimensions > 80 MHz subfields to the maximum number of space-time streams, $N_{STS,max}$, minus one supported for the TXVECTOR parameter NUM_STS of an HE NDP sent in channel widths less than or equal to 80 MHz and greater than 80 MHz, respectively; otherwise, set to 0.

— If a STA is an HE beamformee then it shall set the Ng = 16 SU Feedback and Ng = 16 MU Feedback subfields to 1 if it supports including in the HE Compressed Beamforming Report field a SU feed-

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back for a tone grouping of 16 and a MU feedback for a tone grouping of 16, respectively; otherwise, set to 0.

— An HE beamformee shall set the Codebook Size (ϕ, ψ) = {4, 2} SU Feedback and Codebook Size (ϕ, ψ) = {7, 5} MU Feedback subfields to 1 if it supports including in the HE Compressed Beamforming Report field a SU feedback of codebook size (ϕ, ψ) = {4, 2} and a MU feedback of codebook size (ϕ, ψ) = {7, 5}, respectively; otherwise, set to 0.

— If an AP is an HE beamformer then it shall set the Triggered MU Beamforming Feedback subfield to 1 if it supports receiving in the HE Compressed Beamforming Report field a partial bandwidth MU feedback; otherwise, set to 0.

— If a non-AP STA is an HE beamformee then it shall set the Triggered MU Beamforming Feedback subfield to 1 if it supports including in the HE Compressed Beamforming Report field a partial bandwidth MU feedback; otherwise, set to 0.

— If an AP is an HE beamformer then it shall set the Triggered SU Beamforming Feedback and Triggered CQI Beamforming Feedback subfield to 1 if it supports receiving in the HE Compressed Beamforming Report field SU and CQI feedback, respectively, where the feedback is full and partial bandwidth; otherwise, set to 0.

— If a non-AP STA is an HE beamformee then it shall set the Triggered SU Beamforming Feedback and Triggered CQI Beamforming Feedback subfields to 1 if it supports including in the HE Compressed Beamforming Report field SU and CQI feedback, respectively, where the feedback is full and partial bandwidth; otherwise, set to 0.

27.6.3 Rules for HE sounding protocol sequences

An HE beamformer initiates an HE non-trigger-based (non-TB) sounding sequence by sending an individually addressed NDP Announcement frame that contains one STA Info field that is addressed to an HE beamformee.

An HE beamformer may initiate an HE non-TB sounding sequence with an HE beamformee to solicit SU feedback over full bandwidth (BW).

An HE beamformer may initiate an HE non-TB sounding sequence with an HE beamformee to solicit a feedback variant over full BW only if the feedback variant is computed based on parameters supported by the HE beamformee; otherwise the HE beamformer shall not solicit a feedback variant over full BW computed based on parameters not supported by the HE beamformee (see 27.6.1a (Sounding sequences and support)).

An HE beamformer shall not initiate an HE non-TB sounding sequence to solicit any feedback variant over partial BW from an HE beamformee.

An HE beamformer initiates an HE trigger-based (TB) sounding sequence by sending a broadcast NDP Announcement frame that contains two or more STA Info fields, where each STA Info field is addressed to an HE beamformee.

An HE beamformer may initiate an HE TB sounding sequence to solicit MU feedback over full BW from an HE beamformee

An HE beamformer may initiate an HE TB sounding sequence to solicit a feedback variant only if the feedback variant is computed based on parameters supported by the HE beamformee; otherwise the HE beamformer shall not solicit a feedback variant computed based on parameters not supported by the HE beamformee (see 27.6.2 (Sounding sequences and support)).

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The HE beamformer shall initiate an HE sounding sequence by transmitting an HE NDP Announcement frame followed by an HE NDP after a SIFS. The HE sounding sequence is a non-TB sounding sequence if the HE NDP Announcement frame is an individually addressed frame; otherwise it is a TB sounding sequence.

An HE AP shall not send an HE NDP Announcement frame with STA Info fields that are addressed to STAs from two or more BSSs of a multiple BSSID set to a STA unless the STA has set the Rx Control Frame To MultiBSS subfield in the HE MAC Capabilities Information field of the HE Capabilities element it transmits to 1.

An AP that transmits an HE NDP Announcement frame addressed to HE STAs shall set the TA field of the frame to the MAC address of the AP, except when dot11MultiBSSIDActivated is true and the HE NDP Announcement frame is directed to STAs from at least two different BSSs of the multiple BSSID set, in which case, the AP shall set the TA field of the frame to the transmitted BSSID.

An AP that transmits an HE NDP Announcement frame shall set the RA field to the broadcast address when the frame includes more than one STA Info field. Otherwise, the AP shall set the RA field to the MAC address of the HE beamformee.

An HE beamformer that transmits an HE NDP Announcement frame to an HE beamformee that is an AP, mesh STA or STA that is a member of an IBSS, shall include one STA Info field in the HE NDP Announcement frame and shall set the AID11 field in the STA Info field of the frame to 0. An HE beamformer that transmits an HE NDP Announcement frame to one or more HE non-AP STA beamformee shall set the AID11 field in each STA Info field to the 11 LSBs of the AID of the non-AP STA to which the STA Info field is addressed to. An HE NDP Announcement frame shall not include more than one STA Info fields that have the same value in the AID11 subfield.

The HE NDP Announcement frame shall indicate the *Ng*, codebook and *Nc* to be used by the intended HE beamformees for the generation of HE compressed beamforming feedback except when the HE NDP Announcement frame contains only one STA Info field, in which case the *Ng*, codebook and *Nc* to be used for the generation of the HE compressed beamforming feedback report shall be determined by the recipient of the HE NDP Announcement frame.

An HE beamformer that transmits an HE NDP Announcement frame with more than one STA Info field shall transmit a BRP Trigger frame a SIFS after the HE NDP to solicit HE compressed beamforming feedback from the intended HE beamformees in the same TXOP. The HE beamformer may send additional BRP Trigger frames to solicit a subset of the HE compressed beamforming feedback in the same TXOP as shown in Figure 27-7 (An example of the sounding protocol with more than one HE beamformee).

An HE beamformer that transmits an HE NDP Announcement frame and sets the Feedback Type And Ng subfield of a STA Info field to indicate MU shall set the Nc subfield of the STA Info field to a value less than or equal to the minimum of:

— The maximum number of supported spatial streams according to the corresponding HE beamformee's Rx HE-MCS Map For ≤ 80 MHz and Rx HE-MCS Map For > 80 MHz subfields in the Supported HE-MCS And NSS Set field of the HE Capabilities element sent by the HE beamformee

— The maximum number of supported spatial streams according to the Rx NSS subfield value in the most recently received Operating Mode Notification frame, Operating Mode Notification element with the Rx NSS Type subfield equal to 0, or OM Control field sent by the corresponding HE beamformee (see 27.8 (Operating mode indication))

— The maximum Nc indicated by the Max Nc subfield in the HE PHY Capabilities Information field of the HE Capabilities element sent by the HE beamformee.

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The HE beamformee indicates the maximum number of space-time streams it can receive in an HE NDP, $N_{STS,max}$, as defined in 27.6.2 (Sounding sequences and support).

An HE beamformer that transmits an HE NDP Announcement frame and sets the Feedback Type And Ng subfield of the STA Info field to indicate MU shall indicate *Ng* = 4 or *Ng* = 16 in the Feedback Type And Ng subfield of the STA Info field (see Table 9-25a (Feedback Type And Ng subfield and Codebook Size subfield encoding)).

An HE beamformer that transmits an HE NDP Announcement frame shall set the RU Start Index and RU End Index subfields in a STA Info field to indicate the starting 26-tone RU and the ending 26-tone RU, respectively, of the solicited HE compressed beamforming feedback (see 9.3.1.20 (VHT/HE NDP Announcement frame format)).

The HE beamformer shall indicate a starting 26-tone RU and an ending 26-tone RU that is equal to the lowest 26-tone RU and the highest 26-tone RU, respectively, to indicate that the feedback is solicited over full bandwidth. The HE beamformer may indicate a starting 26-tone RU and an ending 26-tone RU that is greater than the lowest 26-tone RU and less than the highest 26-tone RU, respectively, to indicate that the feedback is solicited over partial bandwidth.

Each 26-tone RU location is based on the RXVECTOR parameter CH_BANDWIDTH of the HE NDP Announcement when received in an HE PPDU or the RXVECTOR parameter CH_BANDWIDTH_IN_NON_HT when the HE NDP Announcement is received in a non-HT PPDU.

The HE beamformer shall solicit feedback over full bandwidth when the HE NDP Announcement frame has only one STA Info field or when the STA Info field is addressed to an HE beamformee that has indicated no support for partial bandwidth feedback. The HE beamformer may solicit feedback over full bandwidth or partial bandwidth when the STA Info field is addressed to an HE beamformee that has indicated support for partial bandwidth feedback (see 27.6.2 (Sounding sequences and support)). For example, the HE beamformer can request full 80 MHz bandwidth feedback for *Ng* = 4 by setting the RU Start Index and RU End Index subfields in the STA Info field to 0 and 36, respectively, as shown in Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU). For *Ng* = 4 and 160 or 80+80 MHz full bandwidth feedback, the RU Start Index and RU End Index subfields are 0 and 74, respectively.

For 80+80 MHz, feedback is not requested for the gap between the 80 MHz segments.

The HE beamformer shall use a lowest 26-tone RU, which is the lower bound of the starting 26-tone in the RU Start Index subfield of a STA Info field that is equal to the maximum of:

- The minimum 26-tone RU located within the channel width in the VHT Operation Information field of the HE Operation element or VHT Operation element (if present), and within the channel width in the HT Operation element
- The minimum 26-tone RU located within the channel width in the most recently received Operating Mode Notification frame, Operating Mode Notification element with the Rx NSS Type subfield equal to 0, or OMI Control field sent by the corresponding HE beamformee (see 27.8 (Operating mode indication))

The HE beamformer shall use a highest 26-tone RU, which is the upper bound of the ending 26-tone RU in the RU End Index subfield of a STA Info field that is equal to the minimum of:

- The maximum 26-tone RU located within the channel width in the VHT Operation Information field of the HE Operation element or VHT Operation element (if present), and within the channel width in the HT Operation element
- The maximum 26-tone RU located within the channel width in the most recently received Operating Mode Notification frame, Operating Mode Notification element with the Rx NSS Type subfield

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equal to 0, or OMI Control field sent by the corresponding HE beamformee (see 27.8 (Operating mode indication))

An HE beamformer that transmits an HE NDP Announcement frame that has only one STA Info field shall set the Nc subfield to 0 and the Feedback Type And Ng subfield to 0. The HE beamformee that is the intended receiver of an HE NDP Announcement frame that has only one STA Info field shall ignore the values of the Nc subfield, Ng subfield (B26 of the STA Info subfield) and Codebook Size subfield.

An example of the HE non-TB sounding protocol with a single HE beamformee is shown in Figure 27-6 (An example of the sounding protocol with a single HE beamformee).

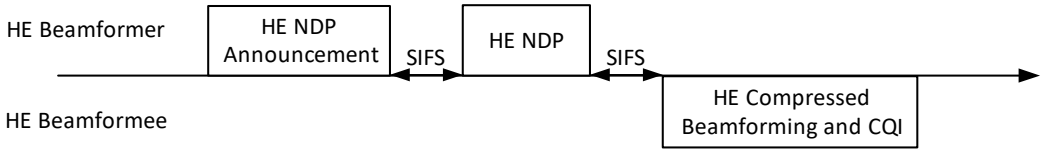


Figure 27-6—An example of the sounding protocol with a single HE beamformee

An HE beamformee that receives an HE NDP Announcement frame from an HE beamformer with which it is associated and that contains the HE beamformee's MAC address in the RA field and also receives an HE NDP a SIFS after the HE NDP Announcement frame shall transmit its HE compressed beamforming feedback a SIFS after the HE NDP. The TXVECTOR parameter CH_BANDWIDTH for the PPDU containing the HE compressed beamforming feedback shall be set to indicate a bandwidth not wider than that indicated by the RXVECTOR parameter CH_BANDWIDTH of the HE NDP.

An example of HE TB sounding protocol with more than one HE beamformee is shown in Figure 27-7 (An example of the sounding protocol with more than one HE beamformee).

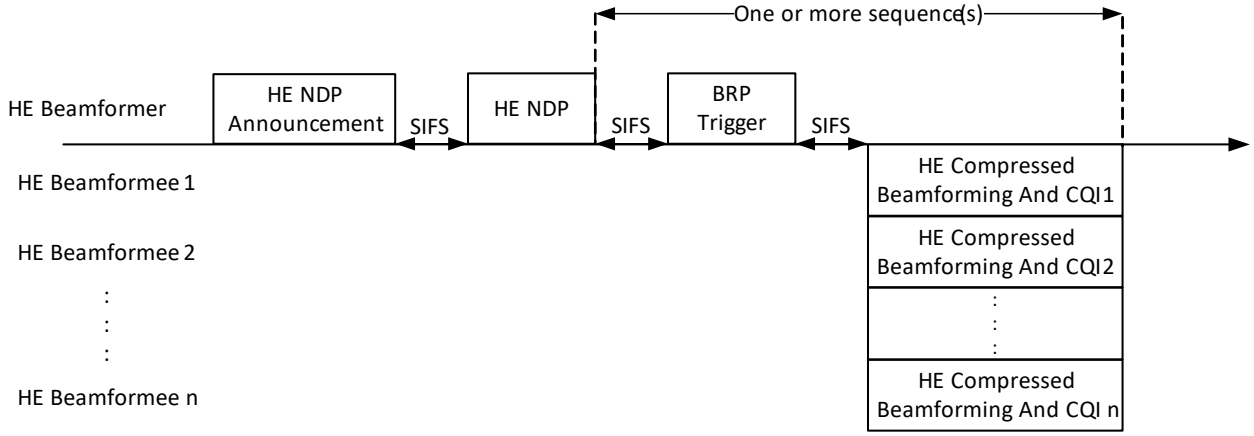


Figure 27-7—An example of the sounding protocol with more than one HE beamformee

A non-AP HE beamformee that receives a broadcast HE NDP Announcement frame from the HE beamformer with which it is associated and that contains the HE beamformee's 11 LSBs of the AID in any of the STA Info fields and also receives an HE NDP a SIFS after the HE NDP Announcement frame shall compute the HE compressed beamforming feedback using the feedback type, *Ng* and codebook size indicated in the received HE NDP Announcement frame. The HE beamformee shall transmit the HE TB PPDU its HE compressed beamforming feedback in response to a BRP Trigger frame that contains the 11 LSBs of the AID of

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the HE beamformee in any of the User Info fields following the rules defined in 27.5.3.3 (STA behavior for UL MU operation) or in response to a Beamforming Report Poll frame addressed to it. If the HE NDP Announcement frame has the TA field set to the transmitted BSSID, and the HE beamformee is a non-AP STA associated to a nontransmitted BSSID that supports receiving Control frames with TA set to the transmitted BSSID, then the HE compressed beamforming feedback sent in response shall have the RA field set to either the nontransmitted BSSID or the transmitted BSSID.

NOTE-A non-AP HE beamformee that transmits an OM Control field with UL MU Disable field set to 1 does not respond to BRP Trigger frames (see 27.8 (Operating mode indication)).

The value of the Sounding Dialog Token Number in the HE MIMO Control field shall be set to the same value as the Sounding Dialog Token Number field in the corresponding HE NDP Announcement frame.

The HE compressed beamforming feedback shall be transmitted in a single HE Compressed Beamforming And CQI frame unless the size of the feedback results in an HE Compressed Beamforming And CQI frame that would exceed 11 454 octets, in which case the feedback shall be segmented as defined in 27.6.4 (Rules for generating segmented feedback).

An HE beamformer shall support a maximum MPDU length for HE Compressed beamforming feedback which is the minimum between 11 454 octets and the maximum length of the HE compressed beamforming feedback that the HE beamformer intends to solicit from its HE beamformees.

An HE beamformer that sends a BRP Trigger frame or Beamforming Report Poll frame shall set the Feedback Segment Retransmission Bitmap fields of the BRP Trigger frame to all ones except when the HE beamformer intends to solicit the retransmission of segmented feedback as defined in 27.6.4 (Rules for generating segmented feedback).

NOTE—The BRP Trigger frame contains one or more User Info fields, each of the which is addressed to an HE beamformee.

27.6.4 Rules for generating segmented feedback

If the HE compressed beamforming feedback solicited by the HE beamformer would result in an HE Compressed Beamforming And CQI frame that exceeds 11 454 octets, then the HE compressed beamforming feedback shall be split into up to 8 feedback segments. Each feedback segment shall be included in a separate HE Compressed Beamforming And CQI frame and shall contain successive portions of the HE compressed beamforming feedback consisting of the HE Compressed Beamforming Report information followed by any MU Exclusive Beamforming Report information. Each feedback segment shall be of equal length except the last feedback segment that may be smaller. Each feedback segment except for the last feedback segment shall contain the maximum number of octets allowed by the HE beamformer's maximum MPDU length capability. Each feedback segment is identified by the value of the Remaining Feedback Segments subfield and the First Feedback Segment subfield in the HE MIMO Control field as defined in 9.4.1.62 (HE MIMO Control field); the other nonreserved subfields of the HE MIMO Control field shall be the same for all feedback segments. All feedback segments shall be sent in a single A-MPDU contained in a PPDU and shall be included in the A-MPDU in the descending order of the Remaining Feedback Segments subfield values.

An AP that sends a BRP Trigger frame shall allocate sufficient resources for the HE beamformee to send all the solicited feedback segments in the HE TB PPDU that is sent in response to the BRP Trigger frame.

An HE beamformer that sends a BRP Trigger frame, in its first attempt to retrieve HE compressed beamforming feedback from an HE beamformee, shall solicit all possible feedback segments by setting all of the bits in the Feedback Segment Retransmission Bitmap subfield to 1 in the User Info field addressed to the HE beamformee.

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An HE beamformer that fails to receive some or all of the feedback segments of the HE compressed beamforming feedback from the HE beamformee, may solicit the selective retransmission of missing feedback segments by sending a Beamforming Report Poll frame or a BRP Trigger frame that indicates in the Feedback Segment Retransmission Bitmap subfield of the User Info field addressed to the HE beamformee the list of feedback segments solicited for retransmission (see 9.3.1.23.2 (Beamforming Report Poll (BRP) variant)).

An HE beamformer that fails to receive the first feedback segment (identified by the First Feedback Segment field set to 1), may solicit the selective retransmission of the missing feedback segments assuming the HE compressed beamforming feedback is split into 8 feedback segments. The HE beamformer may also solicit the retransmission of all feedback segments by setting all of the bits in the Feedback Segment Retransmission Bitmap subfield to 1 in the User Info field addressed to the HE beamformee.

An HE beamformee that transmits HE compressed beamforming feedback including the HE Compressed Beamforming Report information and any MU Exclusive Beamforming Report information in response to a BRP Trigger frame shall either transmit only the feedback segments indicated in the Feedback Segment Retransmission Bitmap field in the Beamforming Report Poll frame or in the User Info field of the BRP Trigger frame addressed to the HE beamformee or transmit all the feedback segments available at the HE beamformee, excluding the feedback segments that do not exist at the HE beamformee.

27.6.5 HE NDP transmission

The TXVECTOR parameters for an HE NDP are as follows:

- FORMAT is set to HE_SU
- APEP_LENGTH is set to 0
- HE_LTF_TYPE is set to either 2x HE-LTF or 4x HE-LTF
- NUM_STS indicates two or more space-time streams when the Feedback Type field in HE MIMO Control field of the preceding HE NDP Announcement frame is set to either SU or MU. Otherwise, NUM_STS is set to any value.
- CH_BANDWIDTH is set to the same value as the TXVECTOR parameter CH_BANDWIDTH in the preceding HE NDP Announcement frame
- GI_TYPE is set to either 0.8 μs or 1.6 μs when HE_LTF_TYPE is 2x HE-LTF and set to 3.2 μs when HE_LTF_TYPE is 4x HE-LTF
- SPATIAL_REUSE is set to SRP_AND_NON-SRG_OBSS-PD_PROHIBITED
- BSS_COLOR is set to the value indicated in the BSS Color subfield of the HE Operation element received or transmitted by the HE AP
- TXOP_DURATION set to either 127 or a value defined in Equation (27-2)

$$\max\left(\min\left(8\left\lfloor\frac{\lceil D_{\text{HE\_NDPA}} - \text{SIFS} - \text{TXTIME}\rceil}{8}\right\rfloor, 504\right), \min\left(128\left\lfloor\frac{\lceil D_{\text{HE\_NDPA}} - \text{SIFS} - \text{TXTIME}\rceil}{128}\right\rfloor, 8448\right)\right) \quad (27\text{-}2)$$

where

$D_{\text{HE\_NDPA}}$ is the value of the Duration/ID field in the MAC header of the preceding HE NDP Announcement frame

TXTIME is the transmission time of an HE NDP defined in Equation (28-127)

When the channel width of an HE NDP is less than or equal to 80 MHz, the number of space-time streams sounded and as indicated by the NUM_STS parameter shall not exceed the value indicated in the Beamformee STS ≤ 80 MHz field in the HE Capabilities element of any intended recipient of the HE NDP. When the

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channel width of an HE NDP is greater than 80 MHz, the number of space-time streams sounded and as indicated by the NUM_STS parameter shall not exceed the value indicated in the Beamformee STS > 80 MHz field in the HE Capabilities element of any intended recipient of the HE NDP. The NUM_STS parameter may be set to any value, subject to the constraint of the previous sentence, regardless of the value of the Supported HE-MCS and NSS Set field of the HE Capabilities element at either the transmitter or recipient of the HE NDP.

The destination of an HE NDP is equal to the RA of the immediately preceding HE NDP Announcement frame.

The source of an HE NDP is equal to the TA of the immediately preceding HE NDP Announcement frame.

27.7 TWT operation

27.7.1 General

Target wake times (TWTs) allow STAs to manage activity in the BSS by scheduling STAs to operate at different times in order to minimize contention between STAs and to reduce the required amount of time that a STA in PS mode needs to be awake.

An HE STA can negotiate individual TWT agreements, as defined in 10.43 (Target wake time (TWT)), subject to the additional rules and restrictions that are defined in 27.7.2 (Individual TWT agreements). An HE STA can negotiate membership in broadcast TWT schedules, as defined in 27.7.3 (Broadcast TWT operation), which can be used as defined in 27.7.3.3 (Rules for TWT scheduled STA), 27.14.2 (Power save with UORA), and 27.14.3 (Opportunistic power save). An HE AP can deliver broadcast TWT parameter sets to non-AP HE STAs, without requiring that an individual TWT agreement has been established between them, as described in 27.7.3 (Broadcast TWT operation).

A STA does need not to be aware of the values of TWT parameters of the TWT agreements of other STAs in the BSS of the STA or of TWT agreements of STAs in other BSSs. A STA does not need to be aware that a TWT service period (SP) can be used to exchange frames with other STAs. Frames transmitted during a TWT SP can be carried in any PPDU format supported by the pair of STAs that have established the TWT agreement corresponding to that TWT SP, including HE MU PPDU, HE TB PPDU, etc.

An HE STA with dot11TWTOptionActivated equal to true shall set:

— The TWT Requester Support subfield to 1 in the HE Capabilities element that it transmits if it supports operating in the role of a TWT requesting STA; otherwise set to 0.

— The TWT Responder Support subfield to 1 in the HE Capabilities elements that it transmits if it supports operating in the role of a TWT responding STA; otherwise set to 0.

— The Broadcast TWT Support subfield to 1 in the HE Capabilities element that it transmits if it supports operating in the role of a TWT scheduled STA or in the role of a TWT scheduling AP; otherwise set to 0.

An HE AP shall set the TWT Responder Support subfields of the Extended Capabilities element and HE Capabilities element to 1.

An HE AP may set the TWT Required subfield to 1 in HE Operation elements it transmits to request TWT participation by all HE STAs that are associated to it and that have declared support for TWT. A STA that supports TWT and is associated with an HE AP from which it receives an HE Operation element whose TWT Required subfield is 1 shall either negotiate individual TWT agreements, as defined in 27.7.2 (Individual TWT agreements), or participate in broadcast TWT operation, as defined in 27.7.3 (Broadcast TWT operation).

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NOTE—The AP sets the TWT Required subfield to 1 when it is unavailable outside of TWT SPs (see 27.7.2 (Individual TWT agreements) and 10.43.7 (TWT Sleep Setup)).

27.7.2 Individual TWT agreements

An HE STA may negotiate individual TWT agreements with another HE STA as defined in 10.43.1 (TWT overview), except that the STA:

— May set the Responder PM Mode subfield to 1 if it is a TWT responding STA that intends to go to doze state outside of TWT SPs.

  • If the TWT responding STA is an AP then it may set the Responder PM Mode subfield to 1 only if all non-AP STAs that are associated to it indicate support of TWT in the role of a TWT requester and the AP has set the TWT Required subfield to 1 in the HE Operation element it transmits; otherwise it shall set the Responder PM Mode subfield to 0.

  • An AP that sets the Responder PM Mode subfield to 1 follows the rules defined in 10.43.7 (TWT Sleep Setup).

— Shall set the Implicit subfield to 1 and the NDP Paging Indicator subfield to 0 in all TWT elements that it transmits during the TWT setup.

— May set the Trigger subfield to 1 in the TWT element it transmits during the TWT setup to negotiate a trigger-enabled TWT.

  • A successful TWT agreement whose Trigger subfield in the TWT response sent by the AP is 1 is a trigger-enabled TWT; otherwise it is not a trigger-enabled TWT.

— Shall set the TWT Channel subfield in the TWT element it transmits to 0.

— May set the TWT Protection field to 1 to indicate that TXOPs within the TWT SPs shall be initiated with a NAV protection mechanism, such as (MU) RTS/CTS, or CTS-to-self frame; otherwise it shall set it to 0.

— An HE STA shall not use the RAW mechanism for protection of TWT SPs.

An HE STA that successfully sets up a TWT agreement with another HE STA shall follow the rules defined in 10.43.1 (TWT overview) and 10.43.4 (Implicit TWT operation), except that all the additional rules defined in this subclause supersede all the respective rules defined in 10.43.1 (TWT overview) and 10.43.4 (Implicit TWT operation). A TWT or TWT SP that is set up under an implicit TWT agreement is an implicit TWT or implicit TWT SP, respectively (see 10.43.1 (TWT overview)). A TWT or TWT SP that is set up under a trigger-enabled TWT agreement is a trigger-enabled TWT or trigger-enabled TWT SP, respectively.

An HE STA may execute the TWT setup exchanges defined in Table 27-2 (HE individual TWT setup exchange command interpretation) in addition to the exchanges defined in 10.43 (Target wake time (TWT)). An HE STA that supports TWT shall set the Broadcast subfield as indicated in 10.43 (Target wake time (TWT)) or as indicated in Table 27-2 (HE individual TWT setup exchange command interpretation). For all exchanges listed in Table 27-2 (HE individual TWT setup exchange command interpretation), the Wake TBTT Negotiation subfield shall be set to 0.

Table 27-2—HE individual TWT setup exchange command interpretation

Initiating frame: TWT Setup Command field value within a TWT Setup frame transmitted from a first STA to a second STA	Response frame: TWT Setup Command field value within a TWT Setup frame transmitted from the second STA to the first STA	TWT condition after the completion of the exchange

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Table 27-2—HE individual TWT setup exchange command interpretation

Request TWT or Suggest TWT or Demand TWT with Broadcast subfield = 0	Accept TWT with Broadcast subfield = 1	This response is not allowed.
Request TWT with Broadcast subfield = 0	Dictate TWT with Broadcast subfield = 1	No individual TWT agreement exists with the associated TWT Flow identifier. A broadcast TWT schedule exists that uses the TWT parameters identified in the response frame including a Broadcast TWT ID subfield. The broadcast TWT schedule is not necessarily a newly created broadcast TWT schedule. The responding STA will not create any new individual TWT agreement with the requester at this time. The STA transmitting the initiating frame is not a member of the broadcast TWT.
Accept TWT with Broadcast subfield set to 0 and with an individual address in the RA field of the MPDU.	No frame transmitted	The STA receiving this frame now has an individual TWT agreement with the transmitter of the frame where the parameters of the individual TWT agreement are identified by the initiating frame.
Accept TWT with Broadcast subfield set to 1 and with an individual address in the RA field of the MPDU.	No frame transmitted	Only an HE AP is permitted to transmit this sequence. The STA receiving this frame is a member of the broadcast TWT identified by the initiating frame.
Alternate TWT or Dictate TWT with Broadcast subfield = 0	No frame transmitted	The STA receiving this frame is not, through the receipt of this frame, a member of the TWT identified by the initiating frame but can use the information provided to create a request to join a TWT in a subsequent initiating frame that it transmits.
NOTE—Request frame settings not listed in the table are not allowed.		

An HE STA that successfully sets up an individual TWT agreement and operates in PS mode may listen to Beacon frames, but is exempt from the requirements for receiving Beacon frames as defined in 11.2.2.1 (General).

An HE AP may send an unsolicited TWT response frame with the Trigger subfield equal to 1 to a non-AP HE STA that has set the TWT Requester Support subfield to 1 in the HE Capabilities elements that it transmits to the AP. The TWT response frame shall have one of these values in the TWT Command field: Accept TWT, Alternate TWT or Dictate TWT. An unsolicited TWT response frame with TWT Command of Alternate TWT or Dictate TWT contains an advisory notification to the recipient of TWT parameters that are likely to be accepted by the AP if the recipient transmits a subsequent TWT request frame to the AP that includes those TWT parameters. An unsolicited TWT response frame with the TWT Command of Accept TWT creates a TWT agreement between the two STAs. A STA that received an unsolicited TWT response frame with the TWT Command of Accept TWT might transmit a TWT Teardown frame to delete the unsolicited individual TWT agreement.

An HE STA shall not transmit BAT, TACK, or STACK frames.

A TWT requesting STA should not transmit frames to the TWT responding STA outside of negotiated TWT SPs for that TWT agreement and should not transmit frames that are not contained within HE TB PPDUs to the TWT responding STA within trigger-enabled TWT SPs for that TWT agreement.

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NOTE—The non-AP STA decides what frames to transmit within or outside TWT SPs and while it is recommended that the STA not to transmit it is still permitted to do so.

The TWT responding STA of a trigger-enabled TWT agreement shall schedule for transmission of a Trigger frame for the TWT requesting STA, as described in 27.5.3 (UL MU operation), within each TWT SP for that TWT agreement. The TWT responding STA should solicit buffer status reports from the TWT requesting STA at the start of the TWT SP following the procedure described in 27.5.3.6 (HE buffer status feedback operation for UL MU) or as described in 27.5.6 (NDP feedback report procedure). The TWT responding STA that intends to transmit additional Trigger frames during a trigger-enabled TWT SP shall set the Cascade Indication field of the Trigger frame to 1 to indicate that it will transmit another Trigger frame within the same TWT SP. The TWT responding STA shall set the Cascade Indication field to 0 when the Trigger frame is the last Trigger frame of the TWT SP or when the Trigger frame is sent outside of a TWT SP.

NOTE 1—The TWT responding STA might not schedule for transmission of a Trigger frame for the TWT requesting STA when the TWT agreement is not a trigger-enabled TWT agreement or when the TWT requesting STA has sent an OM Control field that has the UL MU disable bit equal to 1 (see 27.8 (Operating mode indication).

NOTE 2— The Trigger frame can also be an UMRS Control field contained in an MPDU carried in a DL MU PPDU, provided that the AP allocates enough resources in the HE TB PPDU for the STA to at least deliver its BSRs in response to the soliciting DL MU PPDU.

A TWT requesting STA transmits an HE TB PPDU as a response to a Trigger frame that is intended for it and is sent during a trigger-enabled TWT SP (see 27.5.3 (UL MU operation)). A TWT requesting STA that is in PS mode and is awake shall include a PS-Poll frame or an APSD trigger frame in the HE TB PPDU if the TWT is an announced TWT unless the STA has already transmitted a PS-Poll or APSD trigger frame or transmitted any other indication that the STA is in the awake state within that TWT SP or has, previous to the TWT SP, otherwise indicated to the AP that it is currently in the awake state. The STA may include other frames in the HE TB PPDU when other rules do not prohibit their inclusion, see 27.5.3 (UL MU operation).

NOTE–A Trigger frame is intended for a TWT requesting STA if it is sent by the AP to which the STA is associated and the frame contains the 12 LSBs of the STA's AID in any of its User Info fields. The Trigger frame can have multiple recipients, each of which is identified by the presence of the 12 LSBs of the recipient's AID in any of its User Info fields (see 27.5.3 (UL MU operation)), and can have in the TA field the MAC address of the transmitted BSSID under the conditions defined in 27.5.3.2.3 (Allowed settings of the Trigger frame fields and UMRS Control field).

A TWT responding STA that receives a PS-Poll frame or an APSD trigger frame or any other indication from a TWT requesting STA that is in PS mode during or before an announced TWT SP that the STA is in the awake state during the TWT SP shall follow the rules defined in 11.2.3.6 (AP operation during the CP) to deliver buffered BUs to the STA except that it may deliver multiple buffered BUs as defined here. A TWT responding STA that sends frames to a TWT requesting STA that is in PS mode during an unannounced TWT SP shall follow the rules defined in 11.2.3.6 (AP operation during the CP) to deliver buffered BUs to the STA except that it may deliver multiple buffered BUs as defined here. A TWT responding STA may deliver multiple buffered BUs to a TWT requesting STA in PS mode during:

— An announced TWT SP, without following the rules regarding the number of buffered BUs to be delivered in 11.2.3.6 (AP operation during the CP) as long as the BU delivery does not exceed the duration of the TWT SP and the TWT requesting STA has indicated that it is awake for that TWT SP and as long as the TWT requesting STA has not entered the doze state (see 27.7.4.2 (TWT information for individual TWT) and 27.7.5 (PS operation during TWT SPs)).

— An unannounced TWT SP, without following the rules regarding the number of buffered BUs to be delivered in 11.2.3.6 (AP operation during the CP) if the BU delivery does not exceed the duration of the TWT SP and as long as the TWT requesting STA has not entered the doze state (see 27.7.4.2 (TWT information for individual TWT) and 27.7.5 (PS operation during TWT SPs)).

NOTE—The TWT responding STA can deliver the buffered BUs in an A-MPDU under a block ack agreement if the TWT is an announced TWT and the TWT requesting STA is awake for that TWT SP, or if the TWT is an unannounced TWT. The TWT responding STA can transmit frames to TWT requesting STA after the end of the TWT SP if the STA is in Active mode.

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A TWT responding STA may transmit to a TWT requesting STA that is in Active mode at any time.

NOTE—A TWT requesting STA that is in the Active mode does not need to transmit a frame during an announced TWT SP to indicate that it is in the awake state.

27.7.3 Broadcast TWT operation

27.7.3.1 General

A TWT scheduling AP is an HE AP with dot11TWTOptionActivated equal to true that sets the Broadcast TWT Support field of the HE Capabilities element it transmits to 1 and that follows the rules in 27.7.3.2 (Rules for TWT scheduling AP), 27.14.2 (Power save with UORA), and 27.14.3 (Opportunistic power save).

A TWT scheduling AP may include a broadcast TWT element in the Beacon frame.

The TWT scheduling AP shall not include the broadcast TWT element in broadcast Probe Response frames unless both of the following conditions are met:

— The AP has dot11FILSOmitReplicateProbeResponses is equal to true

— The TWT Flow Identifier subfield is set to 2 and the AP has scheduled transmission of a Trigger frame with at least one RU with the AID12 subfield equal to 2045 during the next scheduled TWT SP

A TWT scheduling AP may include a TWT element with the Broadcast subfield equal to 1 within an Association Response frame or within a TWT setup frame to assign the recipient STA to a broadcast TWT schedule without having received a request from the STA to become a member of the broadcast TWT schedule.

The TWT scheduling AP shall not include a broadcast TWT element in FILS Discovery frames unless the TWT Flow Identifier subfield is set to 2 and the AP has scheduled transmission of a Trigger frame with at least one RU with the AID12 subfield set to 2045 during the next scheduled TWT SP.

A TWT scheduled STA is an non-AP HE STA that sets the Broadcast TWT Support field of the HE Capabilities element it transmits to 1 and receives a broadcast TWT element transmitted by an HE AP that is a TWT scheduling AP.

A TWT scheduled STA follows the schedule provided by the TWT scheduling AP as described in 27.7.3.3 (Rules for TWT scheduled STA), 27.14.2 (Power save with UORA), and 27.14.3 (Opportunistic power save). A TWT scheduled STA can negotiate the wake TBTT and wake interval for Beacon frames it intends to receive as described in 27.7.3.3 (Rules for TWT scheduled STA) or join a particular broadcast TWT as described below.

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An example of broadcast TWT operation is shown in Figure 27-8 (Example of broadcast TWT operation), where the AP is the TWT scheduling AP and STA 1 and STA 2 are the TWT scheduled STAs. The TWT

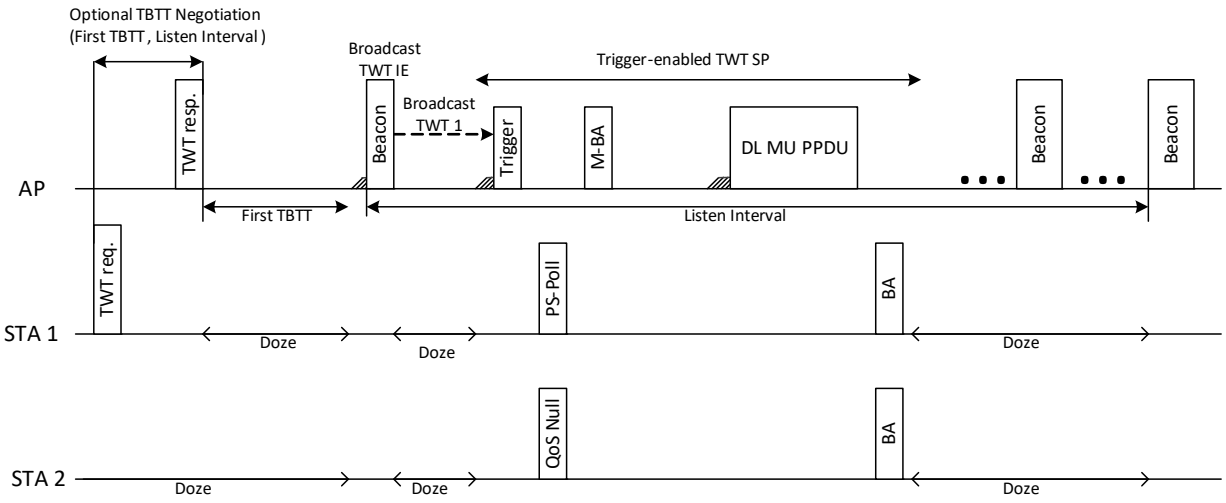


Figure 27-8—Example of broadcast TWT operation

scheduling AP includes a broadcast TWT element in the Beacon frame that indicates a broadcast TWT at or after which the AP intends to send Trigger frames, or DL BUs to the TWT scheduled STAs. STA 1 and STA 2 wake to receive the Beacon determine the broadcast TWT. During the trigger-enabled TWT SP the AP sends a Trigger frame to which STA 1 and STA 2 indicate that they are awake during the TWT SP. STA 1 indicates that it is awake by sending a PS-Poll and STA 2 indicates that it is awake by sending a QoS Null frame in response to the Trigger frame STA 1 and STA 2 receive their DL BUs in a subsequent exchange with the AP and go to doze state outside of this TWT SP.

Each broadcast TWT is uniquely identified by the <broadcast TWT ID, MAC address> tuple, where the broadcast TWT ID is the value of the Broadcast TWT ID subfield and is greater than 0 and the MAC address is the address of the TWT scheduling AP.

Broadcast TWT schedules are advertised by TWT scheduling APs in frames that carry TWT elements with the Broadcast subfield equal to 1 and the Wake TBTT Negotiation subfield equal to 0 as described in 27.7.3.2 (Rules for TWT scheduling AP).

Negotiations to join or leave a Broadcast TWT are performed with an exchange of frames that carry TWT elements with the Broadcast subfield equal to 1 and the Wake TBTT Negotiation subfield equal to 1 as described in 27.7.3.3 (Rules for TWT scheduled STA).

27.7.3.2 Rules for TWT scheduling AP

A TWT scheduling AP may transmit a broadcast TWT advertisement by including a broadcast TWT element in a Beacon frame that is scheduled at a TBTT (see 11.1.3.2 (Beacon generation in non-DMG infrastructure networks)). The TWT scheduling AP shall include one or more TWT parameter sets in the TWT element, and each TWT parameter set may indicate a periodic occurrence of TWTs. The TWT scheduling AP shall set the NDP Paging Indicator subfield to 0, the Broadcast subfield to 1, the Implicit subfield to 1, the Wake TBTT Negotiation subfield to 0 and the Responder PM Mode subfield to 0 in the TWT element (see 10.43.7 (TWT Sleep Setup)). Each TWT parameter set specifies the TWT parameters of a specific broadcast TWT that are valid within a broadcast TWT SP. Each specific broadcast TWT is identified as indicated in 27.7.3.1 (General). Individual STAs may have membership in broadcast TWTs as the result of negotiation with a TWT scheduling AP as described in 27.7.3.1 (General).

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The TWT scheduling AP sets the TWT parameters of each TWT parameter set as described below.

The TWT scheduling AP shall set the TWT Request subfield to 0 and the TWT Setup Command subfield to Accept TWT, except that it may set the TWT Setup Command subfield to:

— Reject TWT when the periodic TWT is being terminated or,

— Alternate TWT when the periodic TWT is being modified

A TWT scheduling AP that sets the TWT Setup Command subfield to Reject TWT should indicate the TBTT at which the periodic broadcast TWT will be terminated by setting the value of the Broadcast TWT Persistence subfield equal to the number of beacon intervals during which the broadcast TWT will continue to exist, rounded up to the nearest integer and not counting the current beacon interval.

A TWT scheduling AP that sets the TWT Setup Command subfield to Alternate TWT should indicate the TBTT at which the periodic broadcast TWT parameter set will be modified by setting the value of the Broadcast TWT Persistence subfield equal to the number of beacon intervals during which the broadcast TWT will continue to operate with the current broadcast TWT parameter set, rounded up to the nearest integer and not counting the current beacon interval.

The TWT scheduling AP shall set the Trigger field to 1 to indicate a trigger-enabled TWT. Otherwise, it shall set the Trigger field to 0 (i.e., the TWT is not a trigger-enabled TWT).

The TWT scheduling AP shall schedule for transmission of a Trigger frame addressed to one or more TWT scheduled STAs during a trigger-enabled TWT SP. A TWT scheduling AP should not include the 12 LSBs of the STA's AID in a User Info field of a Trigger frame transmitted within a broadcast TWT SP unless the STA is in the awake state, has established membership in the broadcast TWT with that Broadcast TWT ID, or has indicated to receive the Beacon, as defined in 27.7.3.4 (Negotiation of wake TBTT and wake interval), preceding the beacon interval that contains this TWT SP.

The TWT scheduling AP that intends to transmit additional Trigger frames during a trigger-enabled TWT SP shall set the Cascade Indication field of the Trigger frame to 1 to indicate that it will transmit another Trigger frame within the same TWT SP. The TWT scheduling AP shall set the Cascade Indication field to 0 when the Trigger frame is the last Trigger frame of the TWT SP or when the Trigger frame is sent outside of a trigger-enabled TWT SP.

NOTE 1—The TWT scheduling AP might not schedule for transmission of a Trigger frame for the TWT scheduled STA when the broadcast TWT is not a trigger-enabled TWT or when the TWT scheduled STA has sent an OM Control field that has the UL MU disable bit equal to 1 (see 27.8 (Operating mode indication)).

NOTE 2—The Trigger frame can also be an UMRS Control field contained in an MPDU carried in a DL MU PPDU, provided that the AP allocates enough resources in the HE TB PPDU for the STA to at least deliver its BSRs in response to the soliciting DL MU PPDU.

The TWT scheduling AP shall set the Flow Type field to 1 to indicate an unannounced TWT. Otherwise, it shall set the Flow Type field to 0 to indicate an announced TWT.

The TWT scheduling AP should schedule delivery of DL BUs during unannounced TWT SPs.

The TWT scheduling AP shall set the TWT Flow Identifier field according to Table 9.262kl (TWT Flow Identifier field for a broadcast TWT element).

A Trigger frame transmitted during a broadcast TWT SP whose TWT parameter set has the TWT Flow Identifier subfield equal to 0 or 3 may contain zero or more random access RU (see 27.5.5 (UL OFDMA-based random access (UORA))). A Trigger frame transmitted during a broadcast TWT SP whose TWT parameter set has the TWT Flow Identifier subfield equal to 1 shall contain no random access RU (see 27.5.5 (UL OFDMA-based random access (UORA))). A Trigger frame transmitted during a broadcast TWT

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SP whose TWT parameter set has the TWT Flow Identifier subfield equal to 2 shall contain at least one random access RU (see 27.5.5 (UL OFDMA-based random access (UORA))). The TWT scheduling AP sends a TIM frame or FILS Discovery frame at the start of a broadcast TWT SP whose TWT parameter set has the TWT Flow Identifier subfield equal to 3 (see 27.14.3 (Opportunistic power save)).

The TWT scheduling AP shall set the TWT field to the TSF timer [4: 19] at which the first TWT is scheduled for this TWT parameter set.

The TWT scheduling AP shall include a nonzero value for the TWT wake interval in the TWT Wake Interval Exponent and TWT Wake Interval Mantissa fields for a periodic TWT and a zero value for an aperiodic TWT.

The TWT parameters are valid for each successive TWT of the periodic TWT or for the only TWT of the aperiodic TWT.

The TWT scheduling AP may include a non-zero value in the Broadcast TWT Persistence subfield for each Broadcast TWT to indicate the number of Beacon Intervals for which the Broadcast TWT schedule will be in existence, counting forward from the current TBTT. The AP may change the value of the Broadcast TWT Persistence subfield for any Broadcast TWT within any transmitted TWT element. If the AP reduces the value of the subfield, it shall not reduce the value by more than one as compared to the value transmitted during the immediately preceding beacon interval. If the AP increases the value of the Broadcast TWT Persistence subfield, it may increase the value by any amount as compared to the value transmitted during the immediately preceding beacon interval.

The TWT scheduling AP shall include a unique value in the Broadcast TWT ID subfield for each Broadcast TWT to allow identification of each Broadcast TWT.

The TWT scheduling AP may set the TWT Protection field to 1 to indicate that TXOPs within the TWT SP shall be initiated with a NAV protection mechanism defined in 10.3.2.4 (Setting and resetting the NAV), 27.2.5 (MU-RTS/CTS procedure), or CTS-to-self as described in 10.3.2.13 (NAV distribution); otherwise it shall set it to 0.

A TWT scheduling AP that receives a PS-Poll or an APSD trigger frame or any other indication from a TWT scheduled STA that is in PS mode that the STA is in the awake state during an announced TWT SP shall follow the rules defined in 11.2.3.6 (AP operation during the CP) to deliver buffered BUs to the STA except that it may deliver multiple buffered BUs as defined here. A TWT scheduling AP that sends frames to a TWT scheduled STA that is in PS mode during an unannounced TWT SP shall follow the rules defined in 11.2.3.6 (AP operation during the CP) to deliver buffered BUs to the STA except that it may deliver multiple buffered BUs as defined here. A TWT scheduling AP may deliver multiple buffered BUs to the TWT scheduled STA during:

— An announced TWT SP, without following the rules regarding the number of buffered BUs to be delivered in 11.2.3.6 (AP operation during the CP) as long as the BU delivery does not exceed the duration of the TWT SP and the TWT scheduled STA has indicated to be awake for that TWT SP and as long as the TWT scheduled STA has not entered the doze state (see 27.7.4.2 (TWT information for individual TWT) and 27.7.5 (PS operation during TWT SPs)).

— An unannounced TWT SP, without following the rules regarding the number of buffered BUs to be delivered in 11.2.3.6 (AP operation during the CP) as long as the BU delivery does not exceed the duration of the TWT SP and as long as the TWT scheduled STA has not entered the doze state (see 27.7.4.2 (TWT information for individual TWT) and 27.7.5 (PS operation during TWT SPs)).

NOTE—The TWT scheduling AP can deliver the buffered BUs in an A-MPDU under a BlockAck agreement if the TWT is an announced TWT and the TWT scheduled STA is awake for that TWT SP, or if the TWT is an unannounced TWT. The TWT scheduling AP can exceed the duration of the TWT SP if the TWT scheduled STA is in Active mode.

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A TWT scheduling AP may transmit to a TWT scheduled STA that is in Active mode at any time.

NOTE—A TWT scheduled STA that is in the Active mode does not need to transmit a frame during an announced TWT SP to indicate that it is in the awake state.

A TWT scheduling AP should indicate Alternate TWT or Reject TWT in the TWT Command Setup field of the broadcast TWT element for as many beacon intervals as needed to exceed the longest interval any STA is expected to not receive Beacon frames either when:

— The TWT parameters of a periodic TWT will change, or

— The periodic TWT specified by that TWT parameter set will be terminated.

A change in the TWT parameter set occurs in a subsequent Beacon frame that is indicated in the Broadcast TWT Persistence subfield.

A TWT scheduling AP that receives a TWT element with the TWT Request field equal to 1, the Broadcast field equal to 1, the Wake TBTT Negotiation field set to 1 and the TWT Command field set to Suggest or Demand may respond with a frame containing a TWT element as shown in Table 27aa (Broadcast TWT Membership exchanges).

A TWT scheduling AP that receives a TWT element with the TWT Request field equal to 1, the Broadcast field equal to 1, the Wake TBTT Negotiation field set to 1 and the TWT Command field set to Reject shall delete the membership of the STA corresponding to the TA of the MMPDU that contained the TWT element from the broadcast TWT schedule that has the Broadcast TWT ID value that is equal to the value of the Broadcast TWT ID field of the TWT element.

NOTE—MMPDUs that contain a broadcast TWT element generated by a TWT scheduling AP can be Probe Response, Beacon, (Re)Association Response, and TWT Setup frames with TWT Request field equal to 0. The Wake TBTT Negotiation subfield is 0 if the TWT element is carried in a broadcast MMPDU and is 1 if the TWT element is carried in an individually addressed MMPDU. The TWT scheduling AP can include a TWT parameter set with Broadcast TWT ID value 0 to indicate a TWT allocated for all STAs, and Broadcast TWT ID greater than 0 to indicate a TWT intended to TWT scheduled STAs that are members of that broadcast TWT.

Valid broadcast TWT announcements are described in Table 27-3 (Broadcast TWT announcements).

Table 27-3—Broadcast TWT announcements

Initiating frame: TWT Setup Command field value within a TWT Setup frame transmitted from a first STA to a second STA, with Broadcast set to 1 and Wake TBTT Negotiation set to 1	Response frame: TWT Setup Command field value within a TWT Setup frame transmitted from the second STA to the first STA with Broadcast set to 1 and Wake TBTT Negotiation set to 1	Condition after the completion of the exchange
Accept TWT with an individual address in the RA field of the MPDU carrying the command	No frame transmitted	Only an HE AP is permitted to transmit this sequence. The STA receiving this frame is a member of the broadcast TWT identified by the initiating frame. A broadcast TWT schedule is either created or already exists and uses the TWT parameters identified in the initiating frame, including a broadcast TWT ID. The broadcast TWT schedule is identified by the broadcast TWT ID and the TA of the initiating frame.

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Table 27-3—Broadcast TWT announcements

Initiating frame: TWT Setup Command field value within a TWT Setup frame transmitted from a first STA to a second STA, with Broadcast set to 1 and Wake TBTT Negotiation set to 1	Response frame: TWT Setup Command field value within a TWT Setup frame transmitted from the second STA to the first STA with Broadcast set to 1 and Wake TBTT Negotiation set to 1	Condition after the completion of the exchange
Alternate TWT	No frame transmitted	When transmitted by a TWT scheduling AP, some of the parameters of the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the initiating frame frame will change in the future. The new parameters will be present in the next frame transmitted by the TWT scheduling AP that has a broadcast TWT with the same broadcast TWT ID and same TA, but with the TWT command value set to Accept TWT.
Reject TWT	No frame transmitted	When transmitted by a TWT scheduling AP, the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the initiating frame frame will be terminated in the future. The termination occurs when a Beacon is transmitted by the TWT scheduling AP that does not include a broadcast TWT with the same broadcast TWT ID and same TA as the initiating frame.

27.7.3.3 Rules for TWT scheduled STA

A TWT element with the Broadcast field equal to 1 is referred to as broadcast TWT element. A TWT scheduled STA that receives a broadcast TWT element in a Beacon frame shall follow the rules defined in this subclause to interact with the TWT scheduling AP.

A TWT scheduled STA should not transmit frames to the TWT scheduling AP outside of broadcast TWT SPs and within trigger-enabled TWT SPs.

A TWT scheduled STA may request to become a member of a broadcast TWT by transmitting a frame to its associated AP that contains a TWT element with the Broadcast subfield set to 1 and the Wake TBTT Negotiation set to 1 and the TWT command field set to Request TWT or Suggest TWT or Demand TWT. The TWT Parameter set indicates the Broadcast TWT ID of the broadcast TWT that the STA is requesting to join. See Table 27-4 (Broadcast TWT membership exchanges).

A TWT scheduled STA may terminate membership in a broadcast TWT by transmitting a frame to its associated AP that contains a TWT element with the Broadcast subfield set to 1 and the Wake TBTT Negotiation set to 1 and the TWT command field set to Reject TWT.

A TWT scheduled STA that receives a TWT element with the TWT Request field equal to 0, the Broadcast field equal to 1,the Wake TBTT Negotiation field equal to 1 and the TWT Command field equal to Accept is a member of the broadcast TWT identified by the <broadcast TWT ID, MAC address> tuple, where the broadcast TWT ID is the value of the Broadcast TWT ID subfield in the TWT element and the MAC address which is the TA of the MMPDU that contained the TWT element is equal to the MAC address of the AP with which the STA is associated, regardless of whether the TWT scheduled STA had previously transmit-

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ted a corresponding TWT element to the AP with the value Suggest TWT or Demand TWT in the TWT Command field.

Valid broadcast TWT membership exchanges are described in Table 27-4 (Broadcast TWT membership exchanges). In addition to the exchanges shown in Table 27-4 (Broadcast TWT membership exchanges), the TWT scheduling AP may respond to an initiating frame that solicits membership in a broadcast TWT schedule with an indication or solicitation of the establishment of an individual TWT agreement.

Table 27-4—Broadcast TWT membership exchanges

Initiating frame: TWT Setup Command field value within a TWT Setup frame transmitted from a first STA to a second STA, with Broadcast set to 1 and Wake TBTT Negotiation set to 1	Response frame: TWT Setup Command field value within a TWT Setup frame transmitted from the second STA to the first STA with Broadcast set to 1 and Wake TBTT Negotiation set to 1	Condition after the completion of the exchange
Demand TWT	Accept TWT	A broadcast TWT schedule exists or has been created with the TWT parameters indicated in the initiating frame and repeated in the responding frame. The STA transmitting the initiating frame is a member of the Broadcast TWT schedule identified by the Broadcast TWT ID and the TA of the response frame.
Request TWT or Suggest TWT	Accept TWT	A broadcast TWT schedule exists or has been created with the TWT parameters indicated in the response frame. The STA transmitting the initiating frame is a member of the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the response frame.
Suggest TWT	Alternate TWT	No new broadcast TWT schedule has been created with the TWT parameters indicated in the initiating frame. The responder is offering an alternative set of parameters vs. those indicated in the initiating frame, as a means of negotiating TWT parameters with the requester. The TWT scheduled STA can send a new request with any set of TWT parameters and the TWT scheduling AP might entertain the creation of a new broadcast TWT schedule using the parameters indicated in the responding frame.
Request TWT or Demand TWT	Alternate TWT	This response is not allowed.
Suggest TWT or Demand TWT	Dictate TWT	A broadcast TWT schedule is either created or already exists and is using the TWT parameters identified in the response frame, including a broadcast TWT ID. The TWT scheduling STA will not create any new broadcast TWT schedule with the TWT scheduled STA at this time. The STA transmitting the initiating frame is not a member of the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the response frame.

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Table 27-4—Broadcast TWT membership exchanges

Request TWT or Suggest TWT or Demand TWT	Reject TWT	The STA transmitting the initiating frame is a not a member of a broadcast TWT identified by the broadcast TWT ID and the TA of the response frame, if such a broadcast TWT exists.
Accept TWT	No frame transmitted	Not permitted to be transmitted by a TWT scheduled STA. When transmitted by a TWT scheduling AP, the recipient STA's membership in the broadcast TWT schedule identified by the broadcast TWT ID and the TA of the initiating frame is established.
Alternate TWT	No frame transmitted	Not permitted to be transmitted by a TWT scheduled STA or a TWT scheduling AP.
Reject TWT	No frame transmitted	When transmitted by a TWT scheduled STA, the transmitting STA's membership in the broadcast TWT schedule identified by the broadcast TWT ID and the RA of the initiating frame frame is terminated.

NOTE 1—MMPDUs that contain a broadcast TWT element generated by a TWT scheduled STA can be (Re)Association Request, and TWT Setup frames with TWT Request field equal to 1. The TWT element has the Broadcast subfield set to 1 and the Wake TBTT Negotiation subfield equal to 1 and the Broadcast TWT ID(s) that the STA intends to join or withdraw.

A TWT scheduled STA that is in PS mode may enter the doze state after receiving a Beacon frame with a TWT element indicating the existence of a broadcast TWT and shall be in the awake state at the broadcast TWT start times which the STA has indicated it will be awake by either establishing a membership for the broadcast TWT with those broadcast TWT IDs, or by negotiating a wake TBTT and wake interval between Beacon frames that the STA receives, as defined in 27.7.3.4 (Negotiation of wake TBTT and wake interval), or has sent a PS-Poll or UPSD trigger frame or any other indication that it is in the awake state during that beacon interval .

A TWT scheduled STA that did not receive a beacon corresponding to a TBTT shall act is if it had received the expected beacon containing a TWT element for a broadcast TWT, if the missed beacon corresponds to a TBTT that is within the next n Beacon Intervals beyond the most recently received Beacon that included a TWT element for that broadcast TWT, where n is equal to one plus the value of the Broadcast TWT Persistence subfield of the corresponding Broadcast TWT, except that n is infinite when the value of the subfield is 7. The value of the Broadcast TWT Persistence subfield is dynamic.

A TWT scheduled STA transmits an HE TB PPDU as a response to a Trigger frame that is intended for it and is sent during a trigger-enabled TWT SP (see 27.5.3 (UL MU operation)). A TWT scheduled STA that is in PS mode and is awake during an announced TWT SP shall include a PS-Poll frame or an APSD trigger frame in the HE TB PPDU if it intends to solicit buffered BUs from the TWT scheduling AP (see 11.2.2.8 (Receive operation for STAs in PS mode during the CP)) unless the STA has already transmitted a PS-Poll or APSD trigger frame or transmitted any other indication that the STA is in the awake state within that announced TWT SP.A TWT scheduled STA that is in PS mode shall transition to the awake state at the start of an unannounced TWT SP of which it is a member.

NOTE 2—A TWT scheduling AP sets the bit in the TIM element of the Beacon frame that corresponds to the AID of the TWT scheduled STA to 1 to indicate that it expects the TWT scheduled STA to solicit available buffered BUs (see 11.2.2.8 (Receive operation for STAs in PS mode during the CP)).

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A TWT scheduled STA should only send frames that satisfy the TWT flow identifier recommendations defined in Table 9.248l1 (TWT Flow Identifier field for a broadcast TWT element) during the corresponding TWT SP(s). Frames sent as a response to a Trigger frame are subject to further restrictions as defined in 27.5.3 (UL MU operation).

27.7.3.4 Negotiation of wake TBTT and wake interval

A TWT scheduled STA that intends to operate in power save mode (see 11.2.2.2 (STA Power Management modes)) may transmit a TWT request frame to the TWT scheduling AP that identifies the wake TBTT of the first Beacon frame and the wake interval between subsequent Beacon frames it intends to receive. The TWT request frame shall contain:

— The Wake TBTT Negotiation subfield equal to 1 and the TWT Command field to Suggest TWT or Demand TWT, the Broadcast subfield equal to 0, and

— The requested first wake TBTT in the Target Wake Time field,

— The requested wake interval between consecutive TBTTs in the TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields.

— All other fields in the TWT element are reserved.

A TWT scheduling AP that receives a TWT request frame from a STA whose value of the Wake TBTT Negotiation subfield is 1 and Broadcast subfield is 0 shall respond with a TWT response frame that contains either Accept TWT or Reject TWT in the TWT Command field and, in the case of an Accept TWT, it shall also contain:

— The Wake TBTT Negotiation subfield equal to 1, the Broadcast subfield equal to 0, and

— The allocated first wake TBTT in the Target Wake Time field, and

— The allocated wake interval between consecutive TBTTs in the TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields.

— All other fields in the TWT element are reserved.

After successfully completing the negotiation, the TWT scheduled STA may go to doze state until its TSF matches the next negotiated wake TBTT provided that the STA is in power save mode, and no other condition requires the STA to remain awake. The TWT scheduled STA shall be in the awake state to listen to Beacon frames transmitted at negotiated wake TBTTs and shall operate as described in 27.7.3.3 (Rules for TWT scheduled STA).

After receiving the Beacon frame at or after TBTT, the TWT scheduled STA may go to doze state until the next wake TBTT if no other condition requires the STA to remain awake. The TWT scheduled STA may go to doze state after AdjustedMinimumTWTWakeDuration time has elapsed from the TBTT start time if no Beacon frame is received.

Either STA that is a party to an established wake TBTT agreement can tear down the wake TBTT agreement by following the tear down procedure described in 10.43.8 (TWT Teardown)and by setting the Wake TBTT Negotiation subfield to 1 in the TWT Teardown frame.

Table 27ab (Wake TBTT Negotiation Exchanges) summarizes the interactions between devices that negotiate a Wake TBTT agreement.

27.7.4 Use of TWT Information frames

27.7.4.1 General

An HE STA may transmit a TWT Information frame to its peer STA during an individual TWT session, broadcast TWT session, or at any time as defined in 27.7.4.2 (TWT information for individual TWT),

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Table 27-5—Wake TBTT negotiation exchanges

Initiating frame	Response frame	
TWT Setup Command field value within a TWT Setup frame transmitted from a first STA to a second STA, with Broadcast set to 0 and Wake TBTT Negotiation set to 1	**TWT Setup Command field value within a TWT Setup frame transmitted from the second STA to the first STA with Broadcast set to 0 and Wake TBTT Negotiation set to 1**	**Condition after the completion of the exchange**
Request TWT	Accept TWT or Alternate TWT or Dictate TWT or Reject TWT or no response	This exchange is not allowed.
Demand TWT or Suggest TWT	Accept TWT	A Wake TBTT agreement has been created with the Wake TBTT parameters indicated in the initiating frame.
Demand TWT or Suggest TWT	Reject TWT	No Wake TBTT agreement has been created.
Demand TWT or Suggest TWT	Alternate TWT	No Wake TBTT agreement has been created. The responder is offering an alternative set of parameters vs. those indicated in the initiating frame. The TWT scheduled STA can send a new request with any set of Wake TBTT parameters and the responder might create a Wake TBTT agreement using those parameters.
Reject TWT	None	An existing Wake TBTT agreement between the initiator and the responder has been terminated.

27.7.4.3 (TWT information for broadcast TWT) and 27.7.4.4 (TWT information for flexible TWT), respectively.

The TWT Information frame shall have the Response Requested subfield equal to 0, the Next TWT Request subfield equal to 0, and one of the following:

— A nonzero value in the Next TWT subfield when the frame is transmitted by a TWT responding STA, a TWT scheduling AP, or by any HE STA to a peer STA that supports TWT.

  • The value of the Next TWT shall be selected from existing TWT values for a TWT session if the Flexible TWT Schedule Support field of the peer STA is 0.
  • The Next TWT may contain any nonzero value if Flexible TWT Schedule Support field of the peer STA is 1.

— A Next TWT subfield that is present when the frame is transmitted by a TWT requesting STA, a TWT scheduled STA, or any HE STA to a peer STA that supports TWT.

  • The Next TWT indicates the TWT at which the TWT session is resumed and shall be selected from existing TWT values for that TWT session if the Flexible TWT Schedule Support field of the peer STA is 0.
  • The Next TWT may contain any nonzero value if Flexible TWT Schedule Support field of the peer STA is 1.
    NOTE—In such case, the TWT requesting STA or TWT scheduled STA or peer STA that transmitted the TWT Information frame preserves the PM mode from the time it sent the TWT Information frame to the time it is expected to wake up.

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— A Next TWT subfield that is not present when the frame is transmitted by a TWT requesting STA or a TWT scheduled STA to indicate suspension of the TWT session.

The TWT Information frame may have the Broadcast Reschedule subfield set to 1 to indicate reschedule of all broadcast TWT sessions and a flexible TWT as defined below.

27.7.4.2 TWT information for individual TWT

An HE STA that has an individual TWT agreement may transmit a TWT Information frame to the STA with which it has an agreement. The HE STA sets the fields of the TWT Information frame as defined in Table 27.7.4.1 (General).

A TWT requesting STA that receives a TWT Information frame follows the rules defined in 10.43.4 (Implicit TWT operation). A TWT requesting STA that receives an acknowledgment in response to a TWT Information frame that:

— Does not contain a Next TWT field shall consider that TWT session suspended, and can follow other individual TWT sessions, the procedure in 27.7.3 (Broadcast TWT operation), or the default PS procedure defined in 11.2 (Power management) until the TWT session is resumed.

— Contains a Next TWT field shall resume the corresponding TWT session, starting from the value indicated in the Next TWT field of the transmitted TWT Information frame.

NOTE—The TWT Flow Identifier, together with the MAC addresses of the TWT requesting STA and TWT Responding STA identifies the TWT agreement for which the TWT Information frame is sent (see 10.43.1 (TWT overview)).

A TWT requesting STA that is in PS mode and that transmits a TWT Information frame to a peer STA may transition to doze state after receiving the acknowledgment even if it has previously transmitted a PS-Poll or U-APSD trigger and has not yet received the expected frames from the AP in response and shall resume TWT operation for the corresponding TWT session at the specified TWT indicated in the TWT Information frame. A TWT requesting STA that is in PS mode and that receives a TWT Information frame from a peer STA may go to doze state after transmitting the acknowledgment even if it has previously transmitted a PS-Poll or U-APSD trigger and has not yet received the expected frames from the AP in response and shall resume TWT operation for the corresponding TWT session at the specified TWT indicated in the TWT Information frame.

27.7.4.3 TWT information for broadcast TWT

An HE STA that is a TWT scheduling AP may transmit a TWT Information frame to any of the members of a broadcast TWT schedule. An HE STA that is a TWT scheduled STA may transmit a TWT Information frame to the TWT scheduling AP corresponding to a broadcast TWT schedule established by that STA. The HE STA sets the fields of the TWT Information frame as defined in 27.7.4.1 (General).

A TWT scheduled STA that receives a TWT Information frame that contains a Broadcast Reschedule subfield equal to 1 follows the rules defined in 27.7.3.3 (Rules for TWT scheduled STA), except that it shall use the Next TWT value contained in the received TWT Information frame.

A TWT scheduled STA that receives an acknowledgment in response to a TWT Information frame that contains a Broadcast Reschedule subfield equal to 1 and:

— Does not contain a Next TWT field shall consider all broadcast TWT sessions suspended, and can follow the default PS procedure defined in 11.2 (Power management) until the TWT session is resumed.

— Does contain a Next TWT field shall resume all broadcast TWT sessions, starting from the value indicated in the Next TWT field of the transmitted TWT Information frame.

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NOTE—TWT suspension and resumption as indicated by a TWT Information frame with the Broadcast Reschedule subfield equal to 1 applies to all broadcast TWT sessions of the TWT scheduling AP.

A TWT scheduled STA that is in PS mode and that transmits a TWT Information frame to a peer STA may transition to doze state after receiving the acknowledgment, even if it has previously transmitted a PS-Poll or U-APSD trigger and has not yet received the expected frames from the TWT scheduling AP in response and shall resume TWT operation for the corresponding TWT session at the specified TWT indicated in the TWT Information frame. A TWT scheduled STA that is in PS mode and that receives a TWT Information frame from a TWT scheduling AP may transition to doze state after transmitting the acknowledgment, even if it has previously transmitted a PS-Poll or U-APSD trigger and has not yet received the expected frames from the TWT scheduling AP in response and shall resume TWT operation for the corresponding TWT session at the specified TWT indicated in the TWT Information frame.

27.7.4.4 TWT information for flexible TWT

An HE STA may transmit a TWT Information frame to its peer STA at any time (i.e., without participating in any TWT sessions) if the peer STA has set the Flexible TWT Schedule Support field of the HE Capabilities it transmits. An HE STA may transmit a TWT Information frame to a TWT scheduling AP. The HE STA sets the fields of the TWT Information frame as defined in 27.7.4.1 (General).

A non-AP HE STA that transmits a TWT Information frame with Broadcast Reschedule subfield equal to 1 to a peer STA may go to doze state after receiving the acknowledgment and shall be in the awake state at the specified TWT indicated in the TWT Information frame. A non-AP HE STA that receives a TWT Information frame with Broadcast Reschedule subfield equal to 1 from a peer STA may go to doze state after transmitting the acknowledgment and shall be in the awake state at the specified TWT indicated in the TWT Information frame.

27.7.5 PS operation during TWT SPs

The following rules apply to TWT SPs for both broadcast TWT schedules and individual TWT agreements.

A TWT requesting STA that is not in PS mode and that transmits a frame with the Power Management subfield set to 1 during a TWT SP shall remain in the awake state until the AdjustedMinimumTWTWakeDuration time has elapsed from the TWT SP start time as identified by the TWT requesting STA or until a TWT SP termination event is detected, whichever occurs first.

A TWT requesting STA in PS mode that is awake for an individual TWT SP may transition to the doze state after AdjustedMinimumTWTWakeDuration time has elapsed from the TWT SP start time as identified by the TWT requesting STA even if it has previously transmitted a PS-Poll frame or U-APSD trigger and has not yet received the expected frames from the AP in response.

When a TWT SP termination event is detected within a TWT SP by a STA in PS mode that is participating in the TWT SP, the STA may transition to the doze state without waiting for the expiration of the AdjustedMinimumTWTWakeDuration time as described in 10.43.1 (TWT Overview)., even if it has previously transmitted a PS-Poll frame or U-APSD trigger and has not yet received the expected frames from the AP in response.

A TWT requesting STA or TWT responding STA may terminate an individual TWT SP by transmitting a TWT Information frame as described in 27.7.4 (Use of TWT Information frames). A TWT scheduled STA or TWT scheduling AP may terminate its participation in a broadcast TWT SP by transmitting a TWT Information frame as described in 27.7.4 (Use of TWT Information frames).

In addition to a TWT Information frame that terminates a TWT SP, the following events also terminate a TWT SP:

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1) The transmission by the TWT requesting STA or TWT scheduled STA of an acknowledgement in response to a frame sent by the TWT responding STA or TWT scheduling AP, respectively, that had the EOSP subfield equal to 1

2) The transmission by the TWT requesting STA or TWT scheduled STA of an acknowledgement in response to an individually addressed frame sent by the TWT responding STA or TWT scheduling AP, respectively with the More Data field equal to 0 when the frame does not contain an EOSP subfield

3) The reception of a frame sent by the TWT responding STA or TWT scheduling AP that does not solicit an immediate response and that had an EOSP subfield present with a value equal to 1

4) The reception of an individually addressed frame sent by the TWT responding STA or TWT scheduling AP that does not solicit an immediate response and that had no EOSP subfield present but had the More Data field equal to 0

The classification of a More Data field equal to 0 in an Ack, BlockAck and Multi-STA BlockAck frame as an event that terminates a TWT SP is only possible when both STAs have indicated support of transmitting or receiving the frame with a nonzero More Data subfield, which is indicated in the More Data Ack subfield of the QoS Info field of frames they transmit (see 11.2.2 (Power management in a non-DMG infrastructure network)).

NOTE 1—A STA participating in multiple TWT SPs which overlap in time stays in the awake state until the latest AdjustedMinimumTWTWakeDuration time of all of the TWT SPs expires, except that a TWT termination event causes all of the overlapping TWT SPs to terminate.

A TWT requesting STA or TWT scheduled STA in PS mode that is awake for an announced trigger-enabled TWT SP and did not transmit any indication that it is in the awake state to the TWT responding STA or TWT scheduling AP may transition to the doze state after the reception of a Trigger frame sent by the TWT responding STA or TWT scheduling AP with the Cascade Indication field equal to 0 that is not intended for the TWT requesting STA or TWT scheduled STA. A TWT requesting STA or TWT scheduled STA in PS mode that is awake for an unannounced trigger-enabled TWT SP may transition to the doze state after the reception of a Trigger frame sent by the TWT responding STA or TWT scheduling AP with the Cascade Indication field equal to 0 that is not intended for the TWT requesting STA or TWT scheduled STA.

NOTE 2—A Trigger frame, sent by the TWT scheduling AP, is defined as intended for the TWT scheduled STA when the Trigger frame contains the AID of the STA in one of its Per User Info fields (see 27.5.3 (UL MU operation)), and can have in the TA field the MAC address of the transmitted BSSID under the conditions defined in 27.5.3.2.3 (Allowed settings of the Trigger frame fields and UMRS Control field). Otherwise, the Trigger frame is not intended for the STA. If the Trigger frame contains one or more random access RUs for which the STA can gain access according to 27.5.5 (UL OFDMA-based random access (UORA)) then the STA can follow the rules defined in 27.14.2 (Power save with UORA) to determine an early TWT SP termination event.

27.8 Operating mode indication

27.8.1 General

An HE STA can change its operating mode setting using either operating mode notification (OMN) as described in 11.42 (Notification of operating mode changes), or the operating mode indication (OMI) procedure described in this subclause.When a first STA transmit both OM Control field and Operating Mode field in different PPDUs to a second STA, the second STA shall use the most recently received one to decide the opering mode of the first STA.

OMI is a procedure used between an OMI initiator and an OMI responder. An HE STA that transmits a frame including an OM Control subfield is defined as an OMI initiator. An HE STA that receives a frame including an OM Control subfield is defined as an OMI responder.

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An HE STA may send to a STA that indicated value 1 in the OM Control Support field in its HE Capabilities element an individually addressed QoS Data, QoS Null or Class 3 Management frame that contains the OM Control subfield, after association, to indicate a change in its receive and/or transmit operating parameters. An HE STA with dot11OMIOptionImplemented equal to true implements the reception of an individually addressed QoS Data, QoS Null or Class 3 Management frame that contains the OM Control subfield that indicates a change in receive operating mode (ROM) and/or transmit operating mode (TOM) parameters. An HE STA with dot11OMIOptionImplemented equal to true shall set the OM Control Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element it transmits to 1.

An HE AP shall set dot11OMIOptionImplemented to true and the HE AP shall implement the reception of the OM Control subfield.

An HE STA should not transmit an OM Control subfield and an Operating Mode field in the same PPDU. When a STA transmits both an OM Control field and Operating Mode field, then the OMI responder shall use the channel width and the RX NSS of the most recently OM Control field or Operating Mode field from the OMI initiator.

The OMI initiator shall indicate a change in its ROM parameters by including the OM Control subfield in a QoS Data, QoS Null or Class 3 Management frame that solicits an immediate acknowledgement and is addressed to the OMI responder as defined in 27.8.2 (Receive operating mode (ROM) indication).

NOTE 1—Frames that solicit an immediate acknowledgement are, for example, QoS Null frames and QoS Data frames with ack policy Normal Ack or Implicit Block Ack Request and Action frames.

The OMI initiator supports receiving PPDUs with a bandwidth up to the value indicated by the Channel Width subfield and with a number of spatial streams, *Nss*, that is up to the value indicated by the Rx NSS subfield of the OM Control subfield as defined in 27.8.2 (Receive operating mode (ROM) indication).

The OMI initiator shall indicate a change in its TOM parameters by including the OM Control subfield in a QoS Data, QoS Null or Class 3 Management frame that solicits an immediate acknowledgement frame and is addressed to the OMI responder as defined in 27.8.3 (Rules for transmit operating mode (TOM) indication).

A non-AP STA OMI initiator that sends an OM Control field with UL MU Disable subfield equal to 0, supports transmitting an HE TB PPDU with an RU allocation that is within the operating channel width indicated in the Channel Width subfield and with a number of space-time streams, N_{STS}, that is up to the value indicated by the Tx NSTS subfield of the OM Control subfield as defined in 27.8.3 (Transmit operating mode (TOM) indication).

NOTE 2—To avoid possible frame loss, a first HE STA that sends an OM Control subfield to a second HE STA indicating reduced operating channel width and/or reduced active receive chains can continue with its current operating channel width and active receive chains until it infers that the second STA has processed this notification. The first HE STA might make this inference from either of the following:

— By receiving a frame addressed to itself from the second HE STA in a PPDU with a bandwidth and NSS that are less than or equal to the channel width and NSS, respectively, indicated in the OM Control subfield

— Based on the passage of time in some implementation dependent way, which is outside the scope of this Standard

NOTE 3—It might take a long time for a STA to change its operating mode following the transmission of the OM Control subfield and during that time the STA might not be able to receive frames resulting in frame loss. If a non-AP STA cannot tolerate frame loss during that period it can set the Power Management subfield of the Frame Control field of the frame which carries OM Control subfield to 1 to indicate that the STA has entered power save. When the non-AP STA has completed its operating mode change, it can send another frame (such as a QoS Null) with the Frame Control Power Management subfield set to 0 to indicate that the STA has exited power save.

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27.8.2 Receive operating mode (ROM) indication

The ROM indication allows the OMI initiator to adapt the maximum operating channel width and/or the maximum number of spatial streams, *Nss*, it can receive from the OMI responder.

An OMI initiator that sends a frame that includes an OM Control subfield should change its OMI parameters, Rx NSS and Channel Width, as follows:

— When the OMI initiator changes a ROM parameter from higher to lower, it should make the change for that parameter only after the TXOP in which it received the immediate acknowledgement from the OMI responder.

— When the OMI initiator changes a ROM parameter from lower to higher, it should make the change for that parameter after the TXOP in which it expects to receive acknowledgement from the OMI responder.

An OMI initiator that is an HE AP should be capable of receiving within an operating channel width and with N_{SS} that are up to the values of the most recently transmitted Channel Width subfield and Rx NSS subfield that the OMI initiator has successfully indicated in the OM Control subfield or in the Operating Mode field sent to any associated STA.

NOTE—In the event of transmission failure of the frame containing the OM Control subfield, the OMI initiator attempts the recovery procedure defined in 10.22.2.7 (Multiple frame transmission in an EDCA TXOP).

The OMI responder shall update the operating channel width and the maximum N_{SS} values as obtained from the Channel Width and Rx NSS subfields, respectively, of the most recently received OM Control subfield sent by the OMI initiator to send SU PPDUs and to assign an RU allocation in sent MU PPDUs, subject to restrictions defined in 28.3.3 (OFDMA and SU tone allocation), addressed to the OMI initiator in subsequent TXOPs.

After transmitting the acknowledgement for the frame containing the OM Control subfield, the OMI responder may transmit subsequent SU PPDUs or MU PPDUs that are addressed to the OMI initiator.

NOTE—A subsequent PPDU is a PPDU that is intended for the OMI initiator and need not be the immediately following PPDU.

27.8.3 Rules for transmit operating mode (TOM) indication

The TOM indication allows the OMI initiator to suspend responding to any variant of the Trigger frame and UMRS Control subfields, or to adapt the maximum operating channel width and/or the maximum number of space-time streams, N_{STS}, it can transmit as a response to a Trigger frame and UMRS Control subfield sent by the OMI responder.

An OMI initiator that is a non-AP STA may indicate changes in its transmit parameters by sending a frame that contains the OM Control subfield to the OMI responder. The OMI initiator shall set:

— The UL MU Disable subfield to 1 to indicate suspension of the UL MU operation (see 27.5.3 (UL MU operation); otherwise it shall set the UL MU Disable subfield to 0 to indicate resumption or continuation of participation in UL MU operation.

  • An AP that is an OMI initiator shall set the UL MU Disable subfield to 0.

— The Tx NSTS subfield to the maximum N_{STS} that the STA may use in response to a Trigger frame or frame carrying a UMRS Control subfield.

— The Channel Width subfield indicates the maximum operating channel width that the STA will use for an HE TB PPDU sent in response to a Trigger frame or frame carrying a UMRS Control subfield.

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An OMI initiator that sent the frame including the OM Control subfield should change its TOM parameters, Tx NSS, UL MU Disallow and Channel Width, as follows:

— When the OMI initiator changes a TOM parameter from higher to lower, it should make the change for that parameter only after the TXOP in which it received the immediate acknowledgement from the OMI responder.

— When the OMI initiator changes a TOM parameter from lower to higher, it should make the change for that parameter only after the TXOP in which it expects to receive acknowledgement from the OMI responder.

The TOM parameter UL MU Disable changes from higher to lower when its value changes from value 0 to value 1.

An OMI responder that successfully receives a frame containing an OM Control subfield from an OMI initiator performs the following operations.

The AP OMI responder shall consider the non-AP STA OMI initiator as not responding to any Trigger frame variants or frames carrying a UMRS Control field for subsequent TXOPs (see 27.5.3 (UL MU operation)) when the UL MU Disable subfield is 1 in the received OM Control subfield.

NOTE 1—The STA sets the UL MU Disable subfield to 1 to indicate that it will not respond to any variant of the Trigger frame and will not respond to a UMRS Control field.

NOTE 2—A device may have multiple radios that can result to difficult in-device coexistence challenges. The device might set UL MU Disable subfield to 1 if it has trouble responding to a Trigger frame or frame carrying a UMRS Control field because the timing or high transmit power would cause interference with another radio in the device.

The OMI responder shall consider the OMI initiator as participating in UL MU operation for subsequent TXOPs when the UL MU Disable subfield is 0 in the received OM Control subfield with the following restrictions:

— The maximum N_{STS} that the OMI initiator can transmit in response to a Trigger frame or frame carrying a UMRS Control field is indicated in the Tx NSTS subfield of the OM Control subfield

— The maximum operating channel width over which the OMI initiator can transmit in response to a Trigger frame or frame carrying a UMRS Control field is indicated in the Channel Width subfield of the OM Control subfield

The OMI responder shall indicate a number of spatial streams, N_{SS}, in the Per User Info field of a Trigger frame, which contains the AID of the OMI initiator, that is less than or equal to the N_{STS} that is calculated from the Tx NSTS subfield of the OM Control subfield received from the OMI initiator.

The OMI responder shall indicate an RU allocation in the RU Allocation subfield of the Per User Info field of a Trigger frame or UMRS Control field addressed to the OMI initiator, that is within the operating channel width specified in the Channel Width subfield of the OM Control subfield received from the OMI initiator and subject to the restrictions defined in 28.3.3 (OFDMA and SU tone allocation).

27.9 Spatial reuse operation

27.9.1 General

The objective of HE spatial reuse operation is to allow the medium to be reused more often between OBSSs in dense deployment scenarios by the early identification of signals from overlapping basic service sets (OBSSs) and interference management.

There are two independent spatial reuse modes, one called OBSS_PD-based spatial reuse and the other called SRP-based spatial reuse.

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An HE AP participating in spatial reuse may request an associated non-AP HE STA to gather information regarding the neighborhood by sending a Beacon request (see 9.4.2.21.7 (Beacon request)) by following the procedure described in 11.11 (Radio measurement procedures). An HE AP shall not set a measurement mode in a Beacon request to an associated STA to a mode that the STA has not explicitly indicated support for via the RM Enabled Capabilities element (see 9.4.2.45 (RM Enabled Capabilities element)). An HE AP that sends a Beacon request:

— May request that the non-AP HE STA gather information of BSSs matching a particular BSSID and/or SSID

— May request that the non-AP HE STA generate a report only for the channel the requesting AP is operating on or is considering switching to

— Shall request that the non-AP HE STA include the HE Operation element of neighboring HE APs in order to help determine the BSS Color information of the neighboring APs

An HE AP may use information from Beacon reports from associated STAs to make decisions related to spatial reuse. The exact algorithm is beyond the scope of this specification.

A non-AP HE STA that performs spatial reuse operation shall respond to a Beacon request from its associated AP with a Beacon report as described in 11.11 (Radio measurement procedures).

27.9.2 OBSS_PD-based spatial reuse operation

27.9.2.1 General

If the PHY of a STA issues a PHY-CCA.indication with a value equal to BUSY followed by an RXSTART.indication due to a PPDU reception then the STA's MAC sublayer may a) issue a PHY-CCA-RESET.request primitive before the end of the PPDU and b) not update its NAV timers based on frames carried in the PPDU if all the following conditions are met:

— The STA has not set the TXVECTOR parameter SPATIAL_REUSE to the value SRP_and_NON_SRG_OBSS_PD_PROHIBITED in any HE PPDU it has transmitted in the current beacon period

— The received PPDU is an inter-BSS PPDU (see 27.2.2 (Intra-BSS and inter-BSS frame determination)) and the received PPDU is not a non-HT PPDU carrying a response frame (Ack, BlockAck or CTS frame), or the received PPDU contains a CTS and a PHY-CCA.indication transition from BUSY to IDLE occurred within the PIFS time immediately preceding the received CTS and that transition corresponded to the end of an inter-BSS PPDU that contained an RTS that was ignored following this procedure.

— The SPATIAL_REUSE subfield in the HE-SIG-A (if present) of the received PPDU is not set to SRP_ AND_NON_SRG_OBSS_PD_PROHIBITED

— The RXVECTOR parameter RSSI_LEGACY in the PHY-RXSTART.indication primitive, which defines the received power level measured from the legacy portion of the PPDU, is below the Non-SRG OBSS_PD level (defined in 27.9.2.2 (Adjustment of OBSS_PD and transmit power)).

— The PPDU is not one of the following:

- A non-HE PPDU that carries a frame where the RA field is equal to the STA MAC address
- A non-HE PPDU that carries a group addressed Public Action frame
- A non-HE PPDU that carries an NDP Announcement frame or FTM frame
- An NDP

A STA that takes actions (a) or (b) under the conditions of the previous paragraph is deemed to perform NON_SRG-OBSS_PD-based spatial reuse (see 27.11.6 (SPATIAL_REUSE)).

If the PHY of a STA issues a PHY-CCA.indication with a value equal to BUSY followed by a PHY-RXSTART.indication due to a PPDU reception then the STA's MAC sublayer may a) issue a PHY-CCARE-

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SET.request primitive before the end of the PPDU and b) not update its NAV timers based on frames carried in the PPDU if all the following conditions are met:

— The received PPDU is an Inter-BSS PPDU (see 27.2.2 (Intra-BSS and inter-BSS frame determination))

— The received PPDU is an SRG PPDU (see 27.2.3 (SRG and non-SRG frame determination)

— The most recently received Spatial Reuse Parameter Set element from the AP associated with the STA had the SRG Information Present subfield equal to 1 or the STA is an AP and its most recently transmitted Spatial Reuse Parameter Set element had the SRG Information Present subfield equal to 1

— The RXVECTOR parameter RSSI_LEGACY in the PHY-RXSTART.indication primitive, which defines the received power level measured from the legacy portion of the PPDU is below the SRG OBSS_PD level defined in 27.9.2.2 (Adjustment of OBSS_PD and transmit power)

— The PPDU is not one of the following:

- A non-HE PPDU that carries a frame where the RA field is equal to the STA MAC address
- A non-HE PPDU that carries a Public Action frame
- A non-HE PPDU that carries an NDP Announcement frame or an FTM frame
- An NDP

If the inter-BSS frame is carried in an HE ER SU PPDU (where power of the L-STF/L-LTF symbols is boosted 3 dB), the received power measured based on the non-HE portion of the HE PPDU preamble and captured in the RXVECTOR parameter RSSI_LEGACY in the PHY-RXSTART.indication primitive shall be decreased by 3 dB to compensate for the power boost factor when compared to the OBSS PD level.

The PHY-CCARESET.request primitive shall be issued at the end of the PPDU if the PPDU is an HE SU PPDU or an HE ER SU PPDU and the RXVECTOR parameter SPATIAL_REUSE indicates SR_DELAY.

If the PHY-CCARESET.request primitive is issued before the end of the PPDU, and a TXOP is initiated within the duration of the PPDU, then the TXOP shall be limited to the duration of the PPDU if the PPDU is HE MU PPDU and the RXVECTOR parameter SPATIAL_REUSE indicates SR_RESTRICTED.

27.9.2.2 Adjustment of OBSS_PD and transmit power

Adjusting the OBSS_PD level and transmit power can improve the system level performance and the utilization of the spectrum. When using OBSS_PD-based spatial reuse, an HE STA may adjust the OBSS_PD level in conjunction with its transmit power and shall respect the condition defined in Equation (27-3).

$$OBSS\_PD_{level} \leq max(OBSSPD_{min}, min(OBSSPD_{max}, OBSSPD_{min} + (TXPWR_{ref} - TXPWR))) \quad (27\text{-}3)$$

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The adjustment rule is illustrated in Figure 27-9 (Illustration of the adjustment rules for OBSS_PD and TX_PWR).

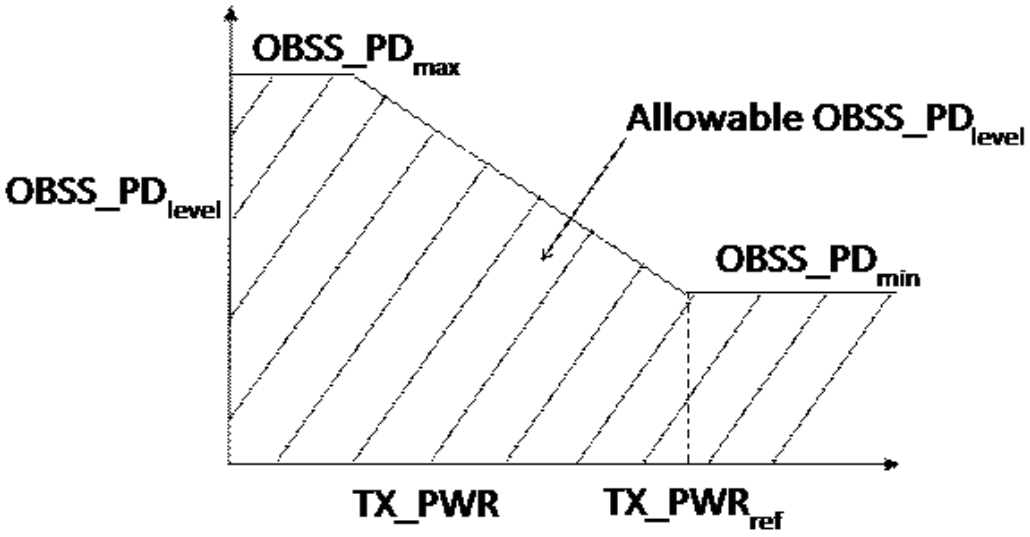


Figure 27-9—Illustration of the adjustment rules for OBSS_PD and TX_PWR

The value of the $OBSS\_PD_{level}$ is applicable to the start of a 20 MHz PPDU received on the primary 20 MHz channel. If the bandwidth of the received PPDU differs from 20 MHz, then the value of the $OBSS\_PD_{level}$ is increased by 10 log (bandwidth/20 MHz).

$TXPWR_{ref}$ = 21 dBm for non-AP STAs.

$TXPWR_{ref}$ = 21 dBm for an AP with the Highest NSS Supported M1 subfield in the Supported HE-MCS and NSS Set field of its HE Capabilities element field equal to or less than 1.

$TXPWR_{ref}$ = 25 dBm for an AP with the Highest NSS Supported M1 subfield in the Supported HE-MCS and NSS Set field of its HE Capabilities element field equal to or greater than 2.

TXPWR is the STA transmission power in dBm at the output of the antenna connector.

An AP may define SRG OBSS PD Min Offset and SRG OBSS PD Max Offset values that are used by its associated STAs and by the AP to derive an SRG OBSS_PD level for determining reception behavior for inter-BSS PPDUs that are determined to be SRG PPDUs. An AP may define a Non-SRG OBSS PD Max Offset value that is used by its associated STAs and by the AP to derive a Non-SRG OBSS_PD level for determining reception behavior for inter-BSS PPDUs that are not determined to be SRG PPDUs. The values of SRG OBSS PD Min Offset, SRG OBSS PD Max Offset and Non-SRG OBSS PD Max Offset are transmitted to associated STAs within the Spatial Reuse Parameter Set element.

An AP transmitting a Spatial Reuse Parameter Set element shall respect the following constraints:

— −82 dBm ≤ −82 + SRG OBSS PD Min Offset dBm ≤ −62dBm
— SRG OBSS PD Min Offset ≤ SRG OBSS PD Max Offset
— SRG OBSS PD Max Offset + −82 dBm ≤ −62 dBm
— Non-SRG OBSS PD Max Offset ≤ SRG OBSS PD Max Offset
— Non-SRG OBSS PD Max Offset + −82 dBm ≤ −62 dBm

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HE STAs shall maintain a Non-SRG OBSS_PD level, with its value selected by respecting the OBSS_PD level condition in Equation (27-3) but with Non-SRG OBSS PD Min and Non-SRG OBSS PD Max in place of OBSS_PDmin and OBSS_PDmax, respectively, where Non-SRG OBSS PD Min and Non-SRG OBSS PD Max are determined according to Table 27-6 (Determining Non-SRG OBSS PD Min and Non-SRG OBSS PD Max values).

Table 27-6—Determining Non-SRG OBSS PD Min and Non-SRG OBSS PD Max values

OBSS_PD SR Disallowed	Non-SRG Offset Present	Value of Non-SRG OBSS PD Min	Value of Non-SRG OBSS PD Max
Spatial Reuse Parameter Set element not received	Spatial Reuse Parameter Set element not received	−82	−62
0	0	−82	−62
0	1	−82	−82 + Non-SRG OBSS PD Max Offset
1	Don't care	−82	-82

HE STAs shall maintain a SRG OBSS_PD level, with its value selected by respecting the OBSS_PD level condition in Equation (27-3) but with SRG OBSS PD Min and SRG OBSS PD Max in place of OBSS_PDmin and OBSS_PDmax, respectively, where SRG OBSS PD Min and SRG OBSS PD Max are determined according to Table 27-7 (Determining SRG OBSS PD Min and SRG OBSS PD Max values).

Table 27-7—Determining SRG OBSS PD Min and SRG OBSS PD Max values

SRG Information Present	Value of SRG OBSS PD Min	Value of SRG OBSS PD Max
Spatial Reuse Parameter Set element not received	N/A see NOTE	N/A see NOTE
0	N/A see NOTE	N/A see NOTE
1	−82 + SRG OBSS PD Min Offset	−82 + SRG OBSS PD Max Offset
NOTE—When SRG Information is not present, a STA cannot determine a PPDU to be SRG and so will not use SRG OBSS PD Min or SRG OBSS PD Max values.		

STAs which receive a Spatial Reuse Parameter Set information element from their associated AP that has a value of 1 in the SRP Disallowed subfield shall not perform SRP-based SR transmissions.

The Spatial Reuse Parameter Set element is optionally present in Beacons, Probe Responses and (Re)Association responses.

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27.9.2.3 OBSS_PD SR transmit power restriction period

If a STA ignores an inter-BSS PPDU following the procedure in 27.9.2.1 (General), using a chosen SRG OBSS_PD level, or a chosen non-SRG OBSS_PD level shall start an OBSS_PD SR transmit power restriction period. This OBSS_PD SR transmit power restriction period shall be terminated at the end of the TXOP that the STA gains once its backoff reaches zero.

If a STA starts an OBSS_PD SR transmit power restriction period with a chosen non-SRG OBSS_PD level, the STA's power as measured at the output of the antenna connector shall be equal or lower than the $TXPWR_{max}$, calculated with this chosen non-SRG OBSS_PD level with Equation (27-4), with the appropriate non-SRG parameters according to Table 27-6 (Determining Non-SRG OBSS PD Min and Non-SRG OBSS PD Max values), for the transmissions of any PPDU (including an HE TB PPDU, except when the HE TB PPDU is triggered by a Trigger frame having the CS Required subfield set to 0) until the end of the OBSS_PD SR transmit power restriction period. If a STA starts an OBSS_PD SR transmit power restriction period with a chosen SRG OBSS_PD level, the STA's power as measured at the output of the antenna connector, shall be equal or lower than the $TXPWR_{max}$, calculated with this chosen SRG OBSS_PD level with Equation (27-4), with the appropriate SRG parameters according to Table 27-7 (Determining SRG OBSS PD Min and SRG OBSS PD Max values), for the transmissions of any PPDU (including HE Trigger-Based PPDU) until the end of the OBSS_PD SR transmit power restriction period.

Multiple ongoing OBSS_PD SR transmit power restriction periods may overlap in time.

NOTE 1—The STA can increase but not decrease the chosen SRG OBSS_PD level or non-SRG OBSS_PD level during an OBSS_PD SR transmit power restriction period.

NOTE 2—The STA's power is always equal or lower than the minimum $TXPWR_{max}$ among all $TXPWR_{max}$ from ongoing OBSS_PD SR transmit power restriction periods.

$$TXPWR_{max} = \begin{cases} \text{unconstrained, if } OBSS\_PD_{level} \le OBSS\_PD_{min} \\ TXPWR_{ref} - (OBSS\_PD_{level} - OBSS\_PD_{min}), \text{ if } OBSS\_PD_{max} \ge OBSS\_PD_{level} > OBSS\_PD_{min} \end{cases} \quad (27\text{-}4)$$

NOTE 1—Equation (27-4) is equivalent to the condition defined in Equation (27-3).

NOTE 2—Anytime, even if $TXPWR_{max}$ is unconstrained, the STA has to respect the transmit power restrictions defined by 11.8.6 Transmit power selection.

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An example of OBSS_PD SR operation is shown in Figure 27-10 (Example of OBSS_PD SR operation).

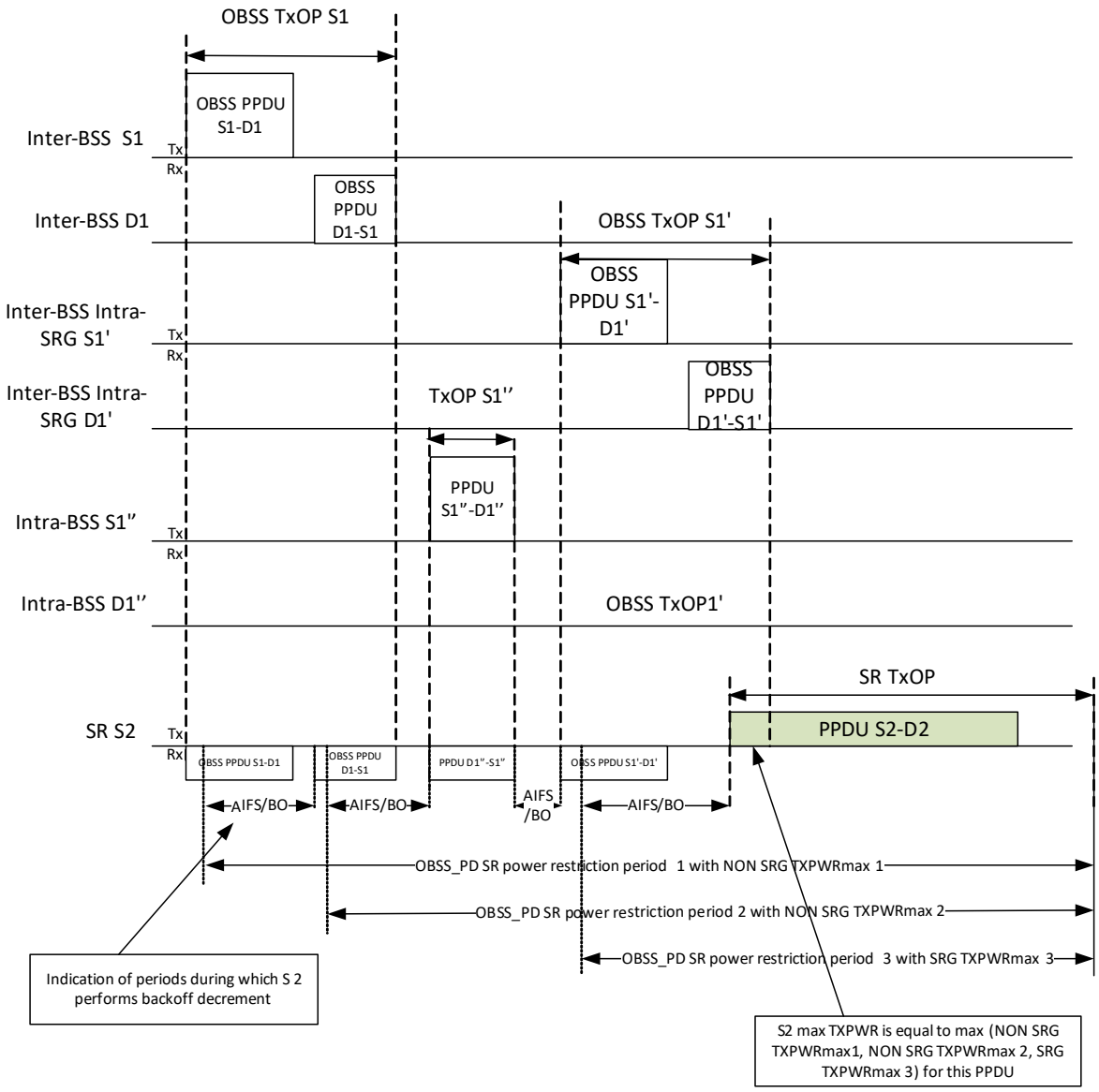


Figure 27-10—Example of OBSS_PD SR operation

27.9.2.4 OBSS_PD-based spatial reuse backoff procedure

If an HE STA ignores an inter-BSS PPDU following the procedure in 27.9.2.1 (General), the HE STA may continue the countdown of an existing backoff procedure right after the PHY-CCARESET.request primitive is sent, provided that the medium condition is not otherwise indicated as BUSY.

27.9.3 SRP-based spatial reuse operation

When the conditions specified in 27.9.3 (SRP-based spatial reuse operation) are met that allow the transmission of an SR PPDU, an HE STA may transmit an SR PPDU to a STA that has indicated support for the role of SR Responder.

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SRP-based SR opportunities are identified from the value of the RXVECTOR parameter SPATIAL_REUSE and/or the contents of a Trigger frame. An HE STA may initiate an SR transmission during an SRP-based SR opportunity using an adjusted transmit power level for the duration of an ongoing PPDU when certain conditions, designed to avoid interfering with the reception of the ongoing PPDU at the recipient are met. When the RXVECTOR parameter SPATIAL_REUSE of the ongoing PPDU has the value SRP_DISALLOW or SRP_ AND_NON_SRG_OBSS_PD_PROHIBITED, no SRP-based SR transmission is allowed for the duration of that PPDU.

An HE-STA supporting SRP-based SR operation indicates support for SRP-based SR operation by setting the SR Responder subfield to 1 in the HE MAC Capabilities Information field of the HE Capabilities element (see Table 9-262aa (Subfields of the HE PHY Capabilities Information field)).

An AP sending a Trigger frame may set the SR field in the Common Info field of the Trigger frame to SRP_DISALLOW or, if permitted, to SRP_ AND_NON_SRG_OBSS_PD_PROHIBITED to forbid OBSS STAs from performing SRP-based SR transmission during the ensuing uplink SRP_PPDU duration. An AP sending a trigger frame shall not set the SR field in the Common Info field of the trigger frame to SR_DELAY.

27.9.3.1 DSRP_PPDU-based spatial reuse initiation

An HE STA identifies a DSRP_PPDU SRP opportunity when the following two conditions are met:

1) The STA receives a PHY-RXSTART.indication corresponding to the reception of a DSRP_PPDU that is identified as an Inter-BSS PPDU (see 27.2.2 (Intra-BSS and inter-BSS frame determination))
2) An SR_PPDU is queued for transmission and the intended transmit power of the SR_PPDU, after normalization to 20 MHz bandwidth (i.e., the transmit power in dBm minus the value, in dB of the intended transmit bandwidth divided by 20 MHz), is below the value of SRP minus RPL, where SRP is the value obtained from Table 28-21 (Spatial Reuse subfield encoding for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU) based on at least one of:
    a) The value of the Spatial Reuse information of the common info field of the Trigger frame of the DSRP_PPDU and the value of RPL is the received power level of the legacy portion of the DSRP_PPDU, normalized to 20 MHz bandwidth
    b) The value of the Spatial Reuse information of the SIGA SRP field of the HE TB PPDU that follows the DSRP_PPDU and the value of RPL is the received power level of the legacy portion of the DSRP_PPDU, normalized to 20 MHz bandwidth

A STA that identifies an SRP opportunity due to the receipt of a DSRP_PPDU may eschew the NAV update operations normally executed based on the receipt of the RXVECTOR parameter TXOP_DURATION and the Trigger frame DUR field value. See Figure 27-11 (DSRP_PPDU spatial reuse). A STA that identifies an SRP opportunity due to the receipt of a DSRP_PPDU may ignore the PHY-RXSTART.indication and the associated HE TB PPDU(s) that are triggered by the Trigger frame of the DSRP_PPDU and that occurs within aSIFSTime + aRxPHYStartDelay + 2 × aSlotTime of the end of the last symbol on the air of the PPDU that contained the Trigger frame, provided that the RXVECTOR BSS_COLOR matches the BSS color of the DSRP_PPDU. A STA that identifies an SRP opportunity due to the receipt of a DSRP_PPDU

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shall not transmit an SR PPDU that terminates beyond the PPDU duration of the HE TB PPDU that is triggered by the Trigger frame of the DSRP_PPDU.

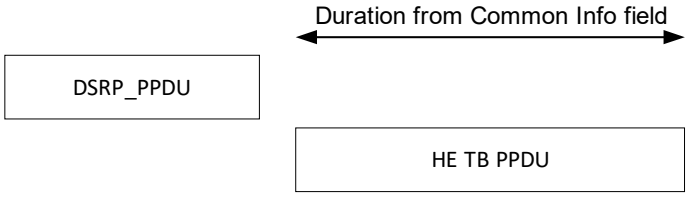


Figure 27-11—DSRP_PPDU spatial reuse

27.9.3.2 SRP_PPDU-based spatial reuse backoff procedure

If an HE STA identifies an SRP opportunity as allowed in 27.9.3.1 (DSRP_PPDU-based spatial reuse initiation), the HE STA may continue the countdown of an existing backoff procedure provided that the medium condition is not otherwise indicated as BUSY. If the HE STA receives another SRP_PPDU during the back-off procedure, it shall suspend its back-off and subsequently, if an SRP opportunity is identified based on the new SRP_PPDU, the STA may resume its backoff procedure. The TXOP that the HE STA gains once its backoff reaches zero shall not extend beyond the SRP opportunity endpoint which is the earliest ending of all of the durations of all of the SRP_PPDUs that were used to confirm the SRP opportunity and all of the durations indicated in the Common Info fields of Trigger frames within all DSRP_PPDUs that were used to confirm the SRP opportunity.

If the HE-STA is already executing its backoff procedure employing $OBSS\_PD_{level}$ as a threshold for determination of an IDLE medium condition prior to the reception of an SRP_PPDU, the intended transmit power of the next SR_PPDU in the transmission queue as measured at the output of the antenna connector shall be equal to or lower than the TXPWRmax, calculated with this specific $OBSS\_PD_{level}$ using Equation (25-1).

After a STA has identified the start of an SRP Opportunity, and until the SRP Opportunity Endpoint is reached, the transmission of any PPDU by the STA shall be limited by the transmit power restrictions identified in 27.9.3 (SRP-based spatial reuse operation).

27.9.3.3 Spatial Reuse field of Trigger frame

An AP with dot11HESRPOptionImplemented set to true that transmits a Trigger frame may determine the value of the Spatial Reuse field value of the Common Info field of the Trigger frame in each 20 MHz bandwidth for 20 MHz, 40 MHz, 80 MHz PPDU or in each 40 MHz bandwidth for 80+80 or 160 MHz PPDU by selecting the row in Table 28-21 (Spatial Reuse subfield encoding for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU) that has a numerical value in the column labeled "Meaning" that is the highest value that is equal to or below the value of the computed MAC parameter SRP_INPUT as follows:

$$\text{SRP\_INPUT} = TXPWR_{AP} + \text{Acceptable Receiver Interference Level}_{\text{AP}} \quad (27\text{-}5)$$

where

$TXPWR_{AP}$ is the transmit power in dBm at the output of the antenna connector of the AP sending the Trigger frame normalized to 20 MHz bandwidth (i.e., transmit power in dBm minus transmit bandwidth divided by 20 MHz bandwidth in dB) for each 20 MHz transmit bandwidth for 20 MHz, 40 MHz, and 80 MHz PPDU or in each of the 40 MHz transmit bandwidths for an 80+80 MHz or 160 MHz PPDU.

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Acceptable Receiver Interference Level$_{AP}$ is a value in dBm normalized to a 20 MHz bandwidth (i.e., minus transmit bandwidth divided by 20 MHz bandwidth in dB) for each 20 MHz transmit bandwidth for 20 MHz, 40 MHz, and 80 MHz PPDU or in each of the 40 MHz transmit bandwidths for an 80+80 MHz or 160 MHz PPDU and should be set to the ambient noise plus interference power level observed at the AP immediately prior to the transmission of the trigger frame plus the SNR margin value which yields a 10% PER for all of the intended MCS(s) in the ensuing uplink HE TB PPDU, minus a safety margin value not to exceed 5 dB as determined by the AP.

An AP with dot11HESRPOptionImplemented set to true that transmits a trigger frame may set the value of the Spatial Reuse field value of the Common Info field of the trigger frame in each 20MHz bandwidth for 20 MHz, 40 MHz, 80 MHz PPDU or in each 40 MHz bandwidth for 80+80 or 160 MHz PPDU to SRP_-DISALLOW.

An AP with dot11HESRPOptionImplemented set to false that transmits a trigger frame shall set the value of the Spatial Reuse field value of the Common Info field of the trigger frame in each 20 MHz bandwidth for 20 MHz, 40 MHz, 80 MHz PPDU or in each 40 MHz bandwidth for 80+80 or 160 MHz PPDU to SRP_-DISALLOW.

27.9.3.4 SR_PPDU transmission requirements

An HE STA that identifies an SRP opportunity shall not transmit a PPDU during the SRP opportunity that elicits a response transmission from a STA from which it has not received an HE Capabilities element with the SR Responder field equal to 1. An HE STA that identifies an SRP opportunity shall not transmit an MPDU that elicits a response transmission during that SRP opportunity that does not include an A-Control field with the SR_PPDU Indication subfield value set to 1.

27.9.3.5 SR_PPDU reception and response transmission requirements

An HE STA that receives a PPDU which contains at least one MPDU with an SR_PPDU Indication subfield value equal to 1 shall not transmit a response PPDU elicited by the received PPDU if all outstanding SRP and OBSS_PD transmit power requirements are not met by the response transmission.

27.9.4 Interaction of OBSS_PD and SRP-based spatial reuse

An HE STA with dot11HESRPOptionImplemented set to true that receives a PPDU that is identified as an inter-BSS PPDU with a value other than SRP_DISALLOW for the RXVECTOR parameter SPATIAL_REUSE and fails to identify an SRP Opportunity based on the receipt of the PPDU shall use a value of −82 dBm/20 MHz or lower for the $OBSS\_PD_{level}$ as it applies to this PPDU.

An HE STA with dot11HESRPOptionImplemented set to true that receives a PPDU that is identified as an inter-BSS PPDU with a value other than SRP_DISALLOW or SR_DELAY for the RXVECTOR parameter SPATIAL_REUSE and identifies an SRP opportunity based on the receipt of the PPDU may use a value of positive infinity or lower for the $OBSS\_PD_{level}$ as it applies to this PPDU and may use a value equal to the receive power of this PPDU plus 1 dB for the ED level for the duration of this PPDU.

An HE STA with dot11HESRPOptionImplemented set to true that receives a PPDU that is identified as an inter-BSS PPDU with a value other than SRP_DISALLOW in the Common Info Field SPATIAL_REUSE of a Trigger frame and fails to identify an SRP opportunity based on the receipt of the PPDU shall use a value of −82 dBm/20 MHz or lower for the $OBSS\_PD_{level}$ as it applies to the HE TB PPDU that is elicited by the Trigger frame.

An HE STA with dot11HESRPOptionImplemented set to true that receives a PPDU that is identified as an Inter-BSS PPDU with a value other than SRP_DISALLOW or SR_DELAY in the Common Info Field SPA-

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TIAL_REUSE of a Trigger frame and identifies an SRP opportunity based on the receipt of the PPDU may use a value of positive infinity or lower for the $OBSS\_PD_{level}$ as it applies to the HE TB PPDU that is elicited by the Trigger frame.

An HE STA with dot11HESRPOptionImplemented set to true that receives a PPDU that is identified as an inter-BSS PPDU with a value equal to SR_DELAY for the RXVECTOR parameter SPATIAL_REUSE shall use a value of negative infinity for the $OBSS\_PD_{level}$ as it applies to this PPDU and shall use a value equal to the receive power of this PPDU minus 1 dB for the ED level for the duration of this PPDU.

27.10 A-MPDU operation

27.10.1 General

A-MPDU operation for an HE PPDU follows the procedures defined in 10.13 (A-MPDU operation) and, additionally, the procedures defined in this subclause.

27.10.2 A-MPDU padding for an HE SU PPDU, HE ER SU PPDU and HE MU PPDU

An HE STA that transmits an DL HE MU PPDU that contains one or more PSDUs, each of which carries an A-MPDU, shall construct the A-MPDUs as described in 10.13.6 (A-MPDU padding for VHT PPDU) except that one or more nonzero length A-MPDU subframes with EOF equal to 1 may be added when the A-MPDU is an ack-enabled A-MPDU (see 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU))

An HE STA that transmits an HE SU PPDU, HE ER SU PPDU or UL HE MU PPDU that contains one A-MPDU, shall construct the A-MPDU as described in 10.13.6 (A-MPDU padding for VHT PPDU) except that one or more nonzero length A-MPDU subframes with EOF equal to 1 may be added when the A-MPDU is an ack-enabled A-MPDU (see 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU)).

The STA shall not add an A-MPDU subframe with EOF set to 1 and with MPDU Length field set to 0 before a nonzero length A-MPDU subframe.

27.10.3 A-MPDU padding for an HE TB PPDU

A non-AP STA that transmits an HE TB PPDU shall construct the PSDU carried in the HE TB PPDU as described in this subclause.

The STA computes the PSDU_LENGTH based on the TXVECTOR parameters.

The STA may add A-MPDU subframes to the A-MPDU contained in the PSDU provided that the following constraints are fulfilled:

- The A-MPDU content constraints (see 10.13.1 (A-MPDU contents) and 27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU)) for the intended recipient
- The Length limit constraints (see 9.7.1 (A-MPDU format) and 10.13.2 (A-MPDU length limit rules)) for the intended recipient
- The MPDU start spacing constraints (see 10.13.3 (Minimum MPDU Start Spacing field)) for the intended recipient

provided that the following conditions are met:

- The A-MPDU subframes have a value greater than 0 in the MPDU Length field, or have a value 0 in the MPDU Length field and a value 0 in the EOF field.
- After incrementing the A-MPDU_Length with the length of each such added A-MPDU subframe, the relationship A-MPDU_Length ≤ PSDU_LENGTH is true.

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Padding is then added such that the resulting A-MPDU contains exactly PSDU_LENGTH octets as follows:

— First, while A-MPDU_Length < PSDU_LENGTH and A-MPDU_Length mod 4 ≠ 0, add an octet to the final A-MPDU subframe's Padding subfield and increment A-MPDU_Length by 1.

— Then, while A-MPDU_Length + 4 < PSDU_LENGTH, add an EOF padding subframe to the EOF Padding Subframes field and increment A-MPDU_Length by 4.

— Finally, while A-MPDU_Length < PSDU_LENGTH, add an octet to the EOF Padding Octets subfield and increment A-MPDU_Length by 1.

The STA shall not add an A-MPDU subframe with EOF set to 1 and with MPDU Length field set to 0 before a nonzero length A-MPDU subframe (see 10.13.7 (Setting the EOF field of the MPDU delimiter) and 27.10.4.3 (Ack-enabled multi-TID A-MPDU operation)).

An A-MPDU pre-EOF padding is constructed from each user from any of the following:

— A-MPDU subframes constructed from the MPDUs available for transmission from any AC that is selected by the STA

— A-MPDU subframes with 0 in the MPDU Length field and 0 in the EOF field

27.10.4 multi-TID A-MPDU and ack-enabled A-MPDU

27.10.4.1 General

An HE STA with dot11MultipleTIDAMPDUOptionImplemented equal to true shall set the Multi-TID Aggregation Support subfield in the HE MAC Capabilities Information field in the HE Capabilities element it transmits to a nonzero value. An HE STA with dot11MultipleTIDAMPDUOptionImlemented equal to false shall set the Multi-TID Aggregation Support subfield of the HE Capabilities element it transmits to 0.

An HE STA with dot11AckEnabledAMPDUOptionImplemented equal to true shall set the Ack-Enabled Aggregation Support subfield in the HE MAC Capabilities Information field in the HE Capabilities element it transmits to 1; otherwise, the HE STA shall set the Ack-Enabled Aggregation Support subfield to 0.

A first HE STA may transmit an ack-enabled A-MPDU to a second HE STA if the first HE STA has received from the second HE STA an HE Capabilities element where the Ack-Enabled Aggregation Support subfield is 1.

An ack-enabled A-MPDU is an A-MPDU that follows the rules in 9.7 (Aggregate MPDU (A-MPDU)) and 10.13 (A-MPDU operation) except that it shall contain:

— One QoS Data frame with the Ack Policy field set to Normal Ack or HTP Ack each carried in an A-MPDU subframe with the EOF field set to 1, or one Action frame carried in an A-MPDU subframe with the EOF field set to 1

— One or more frames in A-MPDU subframes with the EOF field set to 0 that are not under the block ack agreements

An HE STA shall not transmit a multi-TID A-MPDU in a VHT PPDU or a HT PPDU.

A multi-TID A-MPDU is either a non-ack-enabled multi-TID A-MPDU or an ack-enabled multi-TID A-MPDU. A first HE STA may transmit a non-ack-enabled multi-TID A-MPDU to a second HE STA if the first HE STA has received from the second STA an HE Capabilities element where the Multi-TID Aggregation Support subfield is nonzero. A first HE STA may transmit an ack-enabled multi-TID A-MPDU or a non-ack-enabled multi-TID A-MPDU to a second HE STA if the first HE STA has received from the second HE STA an HE Capabilities element where the Multi-TID Aggregation Support subfield is nonzero and where the Ack-Enabled Aggregation Support subfield is 1. Otherwise the first HE STA shall not transmit a multi-TID A-MPDU to the second HE STA.

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An HE STA shall construct a multi-TID A-MPDU as defined in 9.7 (Aggregate MPDU (A-MPDU)) and 10.13 (A-MPDU operation) and following the rules defined in the subclauses below.

An HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to true shall set the Multi-TID Aggregation Support subfield of the HE Capabilities element it transmits to a nonzero value. Otherwise, the HE STA shall set it to 0.

An HE STA shall not send a multi-TID A-MPDU to an HE STA that has the Multi-TID Aggregation Support subfield in the HE Capabilities element equal to 0.

A non-AP STA shall not send a multi-TID A-MPDU in an HE TB PPDU unless it is in response to a Basic Trigger frame where the TID Aggregation Limit field of the User Info field addressed to the STA is nonzero.

An HE STA may aggregate in a multi-TID A-MPDU QoS Data frames with multiple TIDs as defined in Table 9-425 (A-MPDU contents in the data enabled immediate response context) or Table 9-426 (A-MPDU contents in the data enabled no immediate response context).

If the multi-TID A-MPDU is transmitted in an HE TB PPDU, then the number of different TID values for QoS Data frames in the multi-TID A-MPDU shall not exceed the value in the TID Aggregation Limit subfield in the Trigger Dependent User Info field in the Basic Trigger frame that allocated resources for that HE TB PPDU. The multi-TID A-MPDU may contain an Action frame if the TID Aggregation Limit is nonzero and the AP supports reception of ack-enabled multi-TID A-MPDUs.

Any number of QoS Null frame with any TID with which the Ack Policy field is set to No Ack may be aggregated in an A-MPDU carried in the HE TB PPDU regardless of the value of the TID Aggregation Limit subfield and the value of the Preferred AC subfield in the Basic Trigger frame.

NOTE—A QoS Null frame with the Ack Policy field set to Normal Ack or Implicit Block Ack Request is not allowed to be sent in an A-MPDU (as defined in Table 9-425 (A-MPDU contents in the data enabled immediate response context), Table 9-426 (A-MPDU contents in the data enabled no immediate response context) and Table 9-428 (A-MPDU contents MPDUs in the control response context)).

A multi-TID A-MPDU shall not be transmitted in an HE SU PPDU, HE ER SU PPDU or HE MU PPDU, except when the TXOP limit is not zero for the AC that is used to gain access to the medium. This AC is defined as the primary AC. When TXOP limit is not zero then the STA may aggregate QoS Data frames from one or more TIDs in the A-MPDU under the following conditions:

— The A-MPDU shall be carried in either an HE SU PPDU or an HE ER SU PPDU transmitted by STA within the obtained TXOP or an HE MU PPDU transmitted by a non-AP STA within the obtained TXOP

— The A-MPDU shall contain one or more MPDUs with any of the TIDs that correspond to the primary AC

— When no more MPDUs can be aggregated in the A-MPDU from any of the TIDs that correspond to the primary AC then the A-MPDU may additionally contain one or more MPDUs with TIDs that do not correspond to the primary AC if the TIDs correspond to any AC that has a higher priority with respect to the primary AC and the addition of these MPDUs does not cause the STA to exceed the current TXOP duration

The Multi-STA BlockAck frame shall be used to acknowledge the MPDUs in a multi-TID A-MPDU. The rules for Multi-STA BlockAck are defined in subclause 27.4 (HE block acknowledgement procedure).

The responding HE STA shall not aggregate QoS Data frames in the A-MPDU or multi-TID A-MPDU with a number of TIDs that exceeds the value indicated in the TID Aggregation Limit subfield in the Trigger Dependent User Info field of a Basic Trigger frame (9.3.1.23.1 Basic Trigger) intended for it.

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For an HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to true and having a single A-MPDU containing MPDUs with different value of TIDs, the MPDUs with the same TID value may be aggregated in non-contiguous A-MPDU subframes.

When the AP specifies a value defined in Table 9-25j (Preferred AC subfield encoding) in the Preferred AC subfield in the Trigger Dependent User Info field of a Basic Trigger frame, then an HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to true should aggregate MPDUs from any one of the TIDs from the same AC or higher AC as indicated in the Preferred AC subfield of the Trigger Dependent User Info field in the Trigger frame.

NOTE—While it is recommended that the STA transmit QoS Data from the AC that is same or higher than the preferred AC, the STA is still permitted to aggregate QoS Data from an AC lower than the preferred AC.

The STA may aggregate MPDUs from TIDs in other ACs within the remaining time to the HE TB PPDU duration value indicated in the Length subfield in the Common Info field of the received Trigger frame.

When the AP indicates AC_BK in the Preferred AC subfield in the Trigger Dependent User Info field of a Basic Trigger frame, then an HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to true may aggregate MPDUs from any AC/TID or combination of TIDs, up to the limit indicated in the TID Aggregation Limit subfield in Trigger Dependent User Info field of the Trigger frame.

An HE STA that intends to send QoS Data frames from a single TID should select a TID from the same or higher priority AC indicated in the Preferred AC subfield in the Trigger Dependent User Info field of a Basic Trigger frame. If the HE STA has no buffered MPDU for TIDs belonging to the same or higher priority AC indicated in the Preferred AC subfield in the Trigger Dependent User Info field of a Basic Trigger frame, then the HE STA may include MPDUs for a TID belonging to any other AC in that A-MPDU carried in the HE TB PPDU.

NOTE—A multi-TID A-MPDU allows the aggregation of an Action frame regardless of the value indicated in the Multi-TID Aggregation Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element as long as the indicated in the value of the TID Aggregation Limit subfield in the Trigger Dependent User Info field of a the Basic Trigger frame is nonzero.

An HE AP may aggregate MPDUs from any TIDs in multi-TID A-MPDU for DL HE MU PPDU transmission and the number of TIDs in multi-TID A-MPDU shall not be more than the Multi-TID Aggregation Support announced by the recipient.

27.10.4.2 Non-ack-enabled multi-TID A-MPDU operation

For non-ack-enabled A-MPDU operation, a STA shall follow the rules in 9.7 (Aggregate MPDU (A-MPDU)) and 10.13 (A-MPDU operation) except as defined below.

A non-ack-enabled multi-TID A-MPDU is an A-MPDU that meets the following conditions:

- Contains two or more QoS Data frames that belong to two or more block ack agreements and that have the Ack Policy field set to Implicit Block Ack Request, HTP Ack, or Block Ack and are carried in A-MPDU subframes that have the EOF field set to 0
- Does not contain a Management frame that is not an Action No Ack frame
- Does not contain any QoS Data frames with the Ack Policy field set to Normal Ack or HTP Ack carried in an A-MPDU subframe with the EOF field set to 1

NOTE—A non-ack-enabled multi-TID A-MPDU might include other frames such as a Trigger frame, BlockAck frame, or QoS Null frame (see Table 9-425 (A-MPDU contents in the data enabled immediate response context))

The EOF field of each A-MPDU subframe with an MPDU Length field with a nonzero value in a non-ack-enabled multi-TID A-MPDU carried in a HE PPDU shall be set to 0.

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A STA that receives a non-ack-enabled multi-TID A-MPDU responds as defined in 27.4.4 (Per-PPDU acknowledgment selection rules).

27.10.4.3 Ack-enabled multi-TID A-MPDU operation

For ack-enabled multi-TID A-MPDU operation, a STA shall follow the rules in 9.7 (Aggregate MPDU (A-MPDU)), 10.13 (A-MPDU operation) except as defined below.

An ack-enabled multi-TID A-MPDU is an A-MPDU that contains one of the following combinations of frames:

— One or more QoS Data frames with the Ack Policy field set to Implicit Block Ack Request, HTP Ack, or Block Ack belonging to one or more block ack agreements each carried in an A-MPDU subframe with the EOF field set to 0 and one Action frame carried in an A-MPDU subframe with the EOF field set to 1.

— One or more QoS Data frames with the Ack Policy field set to Implicit Block Ack Request, HTP Ack, or Block Ack belonging to one or more block ack agreements each carried in an A-MPDU subframe with the EOF field set to 0, and one or more QoS Data frames with the Ack Policy field set to Normal Ack or HTP Ack each with a different TID and carried in an A-MPDU subframe with the EOF field set to 1.

— Zero or more QoS Data frames with the Ack Policy field set to Implicit Block Ack Request, HTP Ack, or Block Ack belonging to one or more block ack agreements each carried in an A-MPDU subframe with the EOF field set to 0, one or more QoS Data frames with the Ack Policy field set to Normal Ack or HTP Ack each with a different TID and carried in an A-MPDU subframe with EOF field set to 1, and one Action frame carried in an A-MPDU subframe with the EOF field set to 1.

— Zero or more QoS Data frames with the Ack Policy field set to Implicit Block Ack Request, HTP Ack, or Block Ack belonging to one or more block ack agreements each carried in an A-MPDU subframe with the EOF field set to 0, and two or more QoS Data frames with the Ack Policy field set to Normal Ack or HTP Ack each from different TID and carried in an A-MPDU subframe with the EOF field set to 1.

NOTE—An ack-enabled multi-TID A-MPDU might include other frames, such as a Trigger frame, BlockAck frame, or QoS Null frame (see Table 9-425 (A-MPDU contents in the data enabled immediate response context)).

QoS Data frames with the same TID shall have the same Ack Policy field setting.

QoS Data frames with the same TID shall be carried in A-MPDU subframes with the same value in the EOF field setting.

In an ack-enabled multi-TID A-MPDU, the EOF field of each A-MPDU subframe carrying a frame that solicits an Ack frame acknowledgement shall be set to 1. The EOF field of all other A-MPDU subframes carrying frames shall be set to 0.

A STA that receives an ack-enabled multi-TID A-MPDU responds as defined in 227.4.4 (Per-PPDU acknowledgment selection rules).

A STA that transmits an ack-enabled multi-TID A-MPDU that contains at least two MPDUs with different TIDs carried in A-MPDU subframes that have the EOF field equal to 1 shall ignore the immediate response if it is an Ack frame.

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27.11 Setting TXVECTOR parameters for an HE PPDU

27.11.1 STA_ID_LIST

Each element of the TXVECTOR parameter STA_ID_LIST identifies the STA or group of STAs that is the recipient of an RU in the HE MU PPDU. If an RU is intended for a single non-AP STA, then the STA_ID_LIST element for that RU is set to the 11 LSBs of the AID of the STA receiving the PSDU contained in that RU. If an RU is intended for no user, then the STA_ID_LIST element for that RU is set to 2046. If an RU is intended for an AP, then the STA_ID_LIST contains only one element that is set to the 11 LSBs of the AID of the non-AP STA transmitting the PPDU. If an RU is intended for multiple STAs for MU-MIMO then multiple STAIDs in the STA_ID_LIST will refer to the same resource unit (see 27.5.3 (UL MU operation)). If an RU is intended for multiple STAs and carries a single A-MPDU then the STA_ID_LIST element is set as follows:

— For an AP with dot11MultiBSSIDActivated equal to false, if the RU is intended for more than one associated STA in the BSS, the STA_ID_LIST element is set to 0. The AP may include only one element with this value in a DL MU PPDU.

— For an AP with dot11MultiBSSIDActivated equal to true, if the RU is intended for more than one associated STA in any of its BSSs, the STA_ID_LIST element is set to partial virtual bitmap value assigned for the group addressed frame (see 9.4.2.6 (TIM element)). The AP may include only one element for each BSSID of the multiple BSSID set in the HE MU PPDU, and the number of such elements shall not exceed the maximum number of BSSs of the multiple BSSID set.

— For an AP with dot11MultiBSSIDActivated equal to true, if the RU is intended for more than one associated STA on all its BSSs, the STA_ID_LIST element is set to 2047. The AP may include only one element with this value in a DL MU PPDU.

— For an AP with dot11MultiBSSIDActivated equal to false, if the RU is intended for more than one unassociated STA, the STA_ID_LIST element is set to 2045. The AP may include only one element with this value in a DL MU PPDU.

— For an AP with dot11MultiBSSIDActivated equal to true, if the RU is intended for more than one unassociated STA for any of its BSSs, the STA_ID_LIST element is set to 2045. The AP may include only one element with this value in a DL MU PPDU.

27.11.2 UPLINK_FLAG

The Uplink Flag is carried in the TXVECTOR parameter UPLINK_FLAG of an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU and is set as follows:

— A STA transmitting an HE PPDU that is addressed to an AP shall set the TXVECTOR parameter UPLINK_FLAG to 1, except when the HE PPDU is an HE ER SU PPDU with the TXOP Duration field set to all 1s and contains an RTS or CTS frame in which case the STA may set the TXVECTOR parameter UPLINK_FLAG to 0

— A STA transmitting an HE PPDU to a DLS or TDLS peer STA, IBSS member STA, mesh STA, or another non-AP STA shall set the TXVECTOR parameter UPLINK_FLAG to 0

NOTE—A DLS or TDLS peer STA, or IBSS member STA can identify that the HE PPDU is sent in a direct path from the To DS and From DS fields of the MAC header of its MPDU(s)

The TXVECTOR parameter UPLINK_FLAG is not present for an HE TB PPDU.

27.11.3 BEAM_CHANGE

The TXVECTOR parameter BEAM_CHANGE of an HE SU PPDU, HE ER SU PPDU shall be set to 1 if one or more of the following conditions are met:

— The number of spatial streams is greater than 2

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- The PPDU is the first PPDU in a TXOP
- The PPDU carries a Trigger frame

27.11.4 BSS_COLOR

The BSS Color is an identifier of the BSS and is used to assist a receiving STA in identifying the BSS from which a PPDU originates so that the STA can use the channel access rules as described in 27.9 (Spatial reuse operation) or reduce power consumption as described in 27.14.1 (Intra-PPDU power save for non-AP HE STAs) or update the NAV as described in 27.2.4 (Updating two NAVs).

An HE STA transmitting an HE Operation element or a BSS Color Change Announcement element except when the HE STA is a non-AP STA associated with an HE AP shall select a value in the range 1 to 63 to include in either the BSS Color subfield of the HE Operation element or the New BSS Color subfield of the BSS Color Change Announcement element respectively that it transmits and shall maintain that single value of the BSS Color subfield for the lifetime of the BSS or until the BSS color changes as described in 27.16.2.1 (Selecting and advertising a new BSS color). An non-AP HE STA associated with an HE AP that is transmitting an HE PPDU in a direct path to a DLS or TDLS peer STA shall set the BSS Color subfield of the HE Operation element it transmits to the peer STA to the value indicated in the BSS Color subfield of the HE Operation element received from the HE AP.

An HE STA that transmitted an HE Operation element shall set the TXVECTOR parameter BSS_COLOR of an HE PPDU to the value indicated in the BSS Color subfield of its HE Operation element.

An active BSS color is used to set the BSS_COLOR parameter and is the BSS Color field value in the HE Operation element when an HE STA receives an HE Operation element from a peer HE STA. When an HE STA receives a BSS Color Change Announcement element and the BSS color change TBTT has passed, it is the BSS color value received in the BSS Color Change Announcement element (see 27.16.2.1 (Selecting and advertising a new BSS color)) transmitted by a peer HE STA.

An HE STA shall set the TXVECTOR parameter BSS_COLOR for an HE PPDU that is addressed to a peer STA to the active BSS color value, if the HE STA has established any of the following:

- An association with the peer STA
- A TDLS link with the peer STA
- A DLS link with the peer STA
- An IBSS membership with the peer STA

An HE STA that receives an HE PPDU with RXVECTOR parameter BSS_COLOR with a value between 1 and 63 follows the spatial reuse rule described in 27.9 (Spatial reuse operation).

NOTE—An HE STA that received an HE PPDU with the RXVECTOR parameter BSS_COLOR equal to 0 does not follow the spatial reuse rule described in 27.9 (Spatial reuse operation).

An HE STA transmitting an HE SU PPDU or an HE ER SU PPDU for which one or more of the intended recipient STAs is not a member of the transmitting STA's HE BSS shall set the TXVECTOR parameter BSS_COLOR of the HE PPDU to 0.

An HE STA that received an HE SU PPDU or an HE ER SU PPDU with the RXVECTOR parameter BSS_COLOR equal to 0 shall not discard the HE PPDU.

All APs that are members of a multiple BSSID set shall use the same BSS color.

An HE AP that decides to discontinue the use of the BSS color for the BSS that it serves, for example, after detecting a BSS color overlap with an OBSS (see 27.16.2.2 (Detecting and reporting BSS color collision)),

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shall set the value of BSS Color Disabled subfield in the HE Operation element to 1 to inform associated STAs that the BSS Color is disabled; otherwise the AP shall set the BSS Color Disabled subfield to 0.

If the most recently received HE Operation element from the AP to which it is associated contained a value of 1 in the BSS Color Disabled subfield then:

— A non-AP HE STA should use the A1, A2 and Duration/ID fields of the MPDUs contained in the received HE PPDUs instead of the RXVECTOR parameters BSS_COLOR and TXOP_DURATION to determine whether the STA should update the intra-BSS NAV.

— A non-AP HE STA should use the A1, A2 fields of the MPDUs contained in the received HE PPDUs instead of the RXVECTOR parameters BSS_COLOR and STA_ID_LIST to determine whether the STA may go to doze state for the duration of that PPDU (see 27.14.1 (Intra-PPDU power save for non-AP HE STAs)).

A non-AP HE STA may use the RXVECTOR parameter BSS_COLOR of an HE PPDU to determine whether it should update the intra-BSS NAV (see 27.2.4 (Updating two NAVs)) and/or the STA may go to doze state for the duration of the PPDU (see 27.14.1 (Intra-PPDU power save for non-AP HE STAs)) if the most recently received HE Operation element from the AP to which it is associated contained a value of 0 in the BSS Color Disabled subfield.

When the value of TXVECTOR parameter PARTIAL_AID [5:8] in the transmitting VHT PPDU with the TXVECTOR parameter GROUP_ID equal to 63 is not the same as the partial BSS color announced by an HE AP, the HE AP shall set the Partial BSS Color field in the HE Operation element to 0. Otherwise, the HE AP may set the Partial BSS Color subfield in the HE Operation element to 1 (see 27.16.3 (AID assignment)).

27.11.5 TXOP_DURATION

TXOP Duration field is carried in the TXVECTOR parameter TXOP_DURATION of an HE PPDU and indicates duration information for NAV setting and protection of TXOP.

A STA that is not a TXOP responder and that transmits an HE SU PPDU, HE ER SU PPDU, or HE MU PPDU may indicate no duration information for NAV by setting the TXVECTOR parameter TXOP_DURATION to UNSPECIFIED.

A STA that is not a TXOP responder and the transmits an HE SU PPDU, HE ER SU PPDU, or HE MU PPDU that carries a PS-Poll frame shall set the TXVECTOR parameter TXOP_DURATION to UNPSPECIFIED.

A STA that is a TXOP responder that transmits an HE SU PPDU, HE ER SU PPDU, or HE TB PPDU shall set the TXVECTOR parameter TXOP_DURATION to UNSPECIFIED if the RXVECTOR parameter TXOP_DURATION of the soliciting PPDU is UNSPECIFIED.

An HE AP that has set the BSS Color Disabled field in the HE Operation element to 1, shall set the TXVECTOR parameter TXOP_DURATION to UNSPECIFIED for an HE PPDU that it transmits to non-AP STAs associated to it.

An non-AP HE STA should set the TXVECTOR parameter TXOP_DURATION to UNSPECIFIED for an HE PPDU that it transmits to an AP if the BSS Color Disabled field in the HE Operation element most recently received from the AP is1.

A STA that is a TXOP responder that transmits an HE TB PPDU shall not set the TXVECTOR parameter TXOP_DURATION to UNSPECIFIED if any one of the following condition is met:

— The RXVECTOR parameter TXOP_DURATION of the soliciting PPDU is not UNSPECIFIED

— The soliciting PPDU is not an HE PPDU

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When an HE STA, that is not a TXOP responder, transmits an HE PPDU with the TXVECTOR parameter TXOP DURATION not set to UNSPECIFIED and the MAC header of the HE PPDU contains a Duration field it shall set the TXVECTOR parameter TXOP_DURATION to the duration information indicated by the Duration field if the value of the Duration field is smaller than 8448 μs. Otherwise, the TXVECTOR parameter TXOP_DURATION is set to 8448.

NOTE 1—Except for a PS-Poll frame, the Duration/ID field in a Data frame, Management frame and Control frame indicates duration information.

NOTE 2—For a TXOP responder, the Duration field in the MAC header of the response PPDU is set based on the Duration field in the MAC header of the soliciting PPDU as described in 9.2.5.7 (Setting for control response frames) or 9.2.5.8 (Setting for other response frames).

When a TXOP responder transmits either an HE TB PPDU carrying an NDP feedback or a PS-Poll frame with the TXVECTOR parameter TXOP DURATION not set to UNSPECIFIED, it shall calculate the potential duration information and set the TXVECTOR parameter TXOP_DURATION in the HE TB PPDU carrying the NDP feedback or PS-Poll frame to the value of the computed potential duration. The TXOP responder shall calculate potential duration information equal to the duration information indicated by the Duration field of the frame that solicits the response minus the time, in microseconds, between the end of the PPDU carrying the frame that soliciting the HE TB PPDU and the end of the HE TB PPDU. If the calculated potential duration information includes a fractional microsecond, the potential duration information is rounded up to the next higher integer. If the calculated potential duration information is smaller than 8448 μs, the TXVECTOR parameter TXOP_DURATION shall be set to the calculated potential duration information. Otherwise, the TXVECTOR parameter TXOP_DURATION shall be set to 8448.

NOTE 3—The time is equal to SIFS plus the duration of the HE TB PPDU, where the duration of the HE TB PPDU which is defined in Equation (28-126).

27.11.6 SPATIAL_REUSE

The contents of the Spatial Reuse field are carried in the TXVECTOR parameter SPATIAL_REUSE for an HE PPDU indicating spatial reuse information (See 27.9.3 (SRP-based spatial reuse operation)).

For a PPDU with a value of HE_TRIG for the TXVECTOR parameter FORMAT, the SPATIAL_REUSE parameter contains an array of four values. The first value in the array is the SPATIAL_REUSE parameter that applies to the lowest frequency 20 MHz subband, the second value in the array applies to the second lowest frequency 20 MHz subband, the third value in the array applies to the third lowest frequency 20 MHz subband and the fourth value in the array applies to the highest frequency 20 MHz subband when the CH_BANDWIDTH parameter has the value of CBW20, CBW40 or CBW80. The first value in the array applies to the lowest frequency 40 MHz subband, the second value in the array applies to the second lowest frequency 40 MHz subband, the third value in the array applies to the third lowest frequency 40 MHz subband and the fourth value in the array applies to the highest frequency 40 MHz subband when the CH_BANDWIDTH parameter has the value of CBW160 or CBW80+80. When the SPATIAL_REUSE parameter is an array, each value in the array shall individually conform to the rules in this subclause.

An AP with dot11HESRPOptionImplemented set to true that transmits an HE ER PPDU should set the TXVECTOR parameter SPATIAL_REUSE to SRP_DISALLOW.

A non-AP STA with dot11HESRPOptionImplemented set to true that transmits an HE SU PPDU, HE ER PPDU or HE MU PPDU shall set the TXVECTOR parameter SPATIAL_REUSE, when permitted by other conditions, to SRP_AND_NON_SRG_OBSS_PD_PROHIBITED. Otherwise, the non-AP STA shall set it to SRP_DISALLOW.

An HE STA that transmits an HE TB PPDU determines the value of the TXVECTOR parameter SPATIAL_REUSE according to 27.5.3.3 (STA behavior for UL MU operation).

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An HE AP with dot11HESRPOptionImplemented set to true may set the TXVECTOR parameter SPATIAL_REUSE of an MSDU, A-MPDU or MMPDU to the value SRP_DISALLOW to forbid OBSS STAs from performing SRP-based SR transmission during the duration of the corresponding HE SU PPDU, HE ER SU PPDU, or HE MU PPDU.

An HE STA shall set the TXVECTOR parameter SPATIAL_REUSE to SRP_AND_NON-SRG_OBSS-PD_PROHIBITED for an NDP PPDU.

An HE STA shall set the TXVECTOR parameter SPATIAL_REUSE to SRP_AND_NON-SRG_OBSS-PD_PROHIBITED for a PPDU containing an FTM or NDP Announcement frame.

An HE STA that transmits an HE SU PPDU or an HE ER SU PPDU that contains a Trigger frame should set the TXVECTOR parameter SPATIAL_REUSE to SR_DELAY.

An HE STA that transmits an HE MU PPDU that contains a Trigger frame should set the TXVECTOR parameter SPATIAL_REUSE to SR_RESTRICTED.

An HE STA that transmits an HE SU PPDU or HE ER SU PPDU shall not set the TXVECTOR parameter SPATIAL_REUSE to SR_RESTRICTED.

An HE STA that transmits an HE MU PPDU shall not set the TXVECTOR parameter SPATIAL_REUSE to SR_DELAY.

An HE STA that transmits a PPDU that does not contain a Trigger frame shall not set the TXVECTOR parameter SPATIAL_REUSE to SR_DELAY or SR_RESTRICTED.

An HE STA with dot11HESRPOptionImplemented set to false may set the TXVECTOR parameter SPATIAL_REUSE to SRP_DISALLOW for any PPDU that is not an HE TB PPDU or an NDP PPDU or a PPDU containing an FTM or NDP Announcement frame.

An HE non-AP STA may set the TXVECTOR parameter SPATIAL_REUSE of an HE PPDU to SRP_AND_NON_SRG_OBSS_PD_PROHIBITED if the HESIGA_Spatial_reuse_value15_allowed subfield of the SR Control field of the most recently received Spatial Reuse Parameter Set element from its associated AP is equal to 1. If the HESIGA_Spatial_reuse_value15_allowed subfield of the SR Control field of the most recently received Spatial Reuse Parameter Set element from its associated AP is equal to 0, or if STA has not received a Spatial Reuse Parameter Set element from its associated AP, the STA shall not set the TXVECTOR parameter SPATIAL_REUSE of any HE PPDU to SRP_AND_NON_SRG_OBSS_P-D_PROHIBITED.

A STA shall set the TXVECTOR parameter SPATIAL_REUSE of an HE PPDU to SRP_DISALLOW or, if permitted, to SRP_AND-NON-SRG_OBSS_PD_PROHIBITED, if the STA is an HE non-AP STA and the SR Disallowed subfield of the SR Control field of the most recently received Spatial Reuse Parameter Set element from its associated AP is equal to 1.

27.12 HE PPDU post FEC padding and packet extension

An HE STA with dot11PPEThresholdsRequired set to false may set the PPE Thresholds Present subfield in HE Capabilities elements that it transmits to 0.

An HE STA with dot11PPEThresholdsRequired set to true shall set the PPE Thresholds Present subfield in HE Capabilities elements that it transmits to 1.

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A STA that sets the PPE Thresholds Present subfield in HE Capabilities elements that it transmits to 1 shall indicate its minimum post-FEC padding and packet extension duration value per constellation, NSS and RU allocation by setting the subfields of the PPE Thresholds field according to 9.4.2.237 (HE Capabilities element) and using the corresponding values from dot11PPEThresholdsMappingTable.

After receiving the PPE Thresholds field from a second STA, the first STA uses the combination of the PPET8 NSS*n* RU*b* subfield and PPET16 NSS*n* RU*b* subfield values to determine the Nominal Packet Padding (consisting of both post-FEC padding and packet extension) value for HE PPDUs that are transmitted to the second STA using NSS = *n* and an RU allocation corresponding to RU Allocation Index b, for each value of NSS and RU specified by the field. For all values of *n* and *b* for which PPET8 and PPET16 are not present, the Nominal Packet Padding value is 0 for HE PPDUs that are transmitted to the STA using NSS = *n* and an RU allocation corresponding to RU allocation index *b*. The decision of PPE threshold is described in Table 27-8 (PPE thresholds per PPET8 and PPET16).

Table 27-8—PPE thresholds per PPET8 and PPET16

Result of comparison of the constellation index *x* of an HE PPDU with NSS value *n* and RU value Allocation size that corresponds to the RU Allocation index = (*b* + DCM) to the value in the PPET8 NSS*n* RU*m* subfield	**Result of comparison of the constellation index of an HE PPDU with NSS value *n* and RU value Allocation size that corresponds to the RU Allocation index = value (*b* + DCM) to the value in the PPET16 NSS*n* RU*m* subfield**	**Nominal Packet Padding value for an HE PPDU transmitted to this STA using the constellation index = *x*, NSS = *n* and RU Allocation size that corresponds to the RU Allocation index = (*b* + DCM)**
x greater than or equal to PPET8	*x* less than PPET16 or PPET16 equal to None	8 µs
x greater than PPET8 or PPET8 equal to None	*x* greater than equal to PPET16	16 µs
All other combinations not otherwise listed in this table		0
NOTE—DCM = 1 when the HE PPDU uses DCM; DCM = 0 otherwise.		

An HE STA transmitting an HE PPDU provides the nominal packet padding in the TXVECTOR parameter NOMINAL_PACKET_PADDING for the minimal PE calculation (see 28.3.12 (Packet extension)).

A STA transmitting an HE PPDU to a receiving STA shall include a minimum post-FEC padding as determined by the post-FEC padding pre-FEC padding factor (see 28.3.11 (Data field) and after including the post-FEC padding, the transmitting STA shall include a packet extension that yields a total post-FEC padding plus packet extension that corresponds to at least the value indicated in the HE Capabilities element received from the receiving STA.

27.13 Link adaptation using the HLA Control field

This subclause applies to frame exchange sequences that include PPDUs containing an HE variant HT Control field.

A STA that supports HE link adaptation using the HLA Control field shall set the HE Link Adaptation Support subfield in the HE Capabilities Information field in the HE Capabilities element to Unsolicited or Both, depending on its own link adaptation feedback capability. A STA shall not send an MRQ to a STA that has

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not set the HE Link Adaptation Support subfield to Both in the HE Capabilities Information field of the HE Capabilities element. A STA shall not send an unsolicited MFB in any frame that contains an HLA Control field to a STA that has not set the HE Link Adaptation Support subfield to either Unsolicited or Both in the HE Capabilities Information field of the HE Capabilities element.

The MFB requester may set the MRQ subfield to 1 and Unsolicited MFB subfield to 0 in the HLA Control field of a frame to request a STA to provide link adaptation feedback. In each request, the MFB requester shall set the MSI field to a value ranging from 0 to 6. For the MFB requester, how to choose the MSI value is implementation dependent.

The appearance of more than one instance of an HLA Control field with the MRQ field equal to 1 within a single PPDU shall be interpreted by the receiver as a single request for link adaptation feedback.

The MFB requester shall specify the RU index and BW requesting the link adaptation feedback.

On receipt of an HLA Control field with the MRQ subfield equal to 1, an MFB responder computes the HE-MCS, NSS, and DCM of the RU and BW specified in the MRQ and these estimates are based on the same RU of the PPDU carrying the MRQ. The PPDU carrying MRQ shall include the RU requested for MFB. The MFB responder labels the result of this computation with the MSI value from the HLA Control field in the received frame carrying the MRQ. The MFB responder may include the received MSI value in the MSI field of the corresponding response frame. In the case of a delayed response, this allows the MFB requester to associate the MFB with the soliciting MRQ.

An MFB responder that sends a solicited MFB shall set the Unsolicited MFB subfield to 0 and MRQ subfield to 0 in the HLA Control field.

The STA receiving MFB may use the received MFB to compute the appropriate HE-MCS, DCM and NSS.

The MFB responder may send a solicited response frame with any of the following combinations of HE-MCS, NSS, and MSI:

— HE-MCS = 15, NSS = 7, MSI = 7: no information is provided for the immediately preceding MRQ request. This combination is used when the responder is required to use HE variant HT Control field for other protocols and when no MFB is available. It has no effect on the status of any other pending MRQ.

— HE-MCS = 15, NSS = 7, MSI = 0~6: the responder is not now providing, and will never provide, feedback for the request that had the MSI value that matches the MSI value.

— HE-MCS = valid value, NSS = valid value, MSI = 0~6: the responder is providing feedback for the request that had the MSI value that matches the MSI value.

A STA sending unsolicited MFB using the HLA Control field shall set the Unsolicited MFB subfield to 1.

Unsolicited HE-MCS, NSS, DCM, BW, and RU estimates reported of an HLA Control field sent by a STA are computed based on the most recent PPDU received by the STA whose PPDU format, TxBF, and Coding Type, are indicated in the subfileds of the same HLA Control field.

In an unsolicited MFB response the PPDU formats, and Coding Type, subfields are set according to the RXVECTOR parameters of the received PPDU from which the HE-MCS, RU, BW, and NSS are estimated, as follows:

— The PPDU format subfield is set and encoded as follows:

- 0 if the parameter FORMAT is equal to HE_SU
- 1 if the parameter FORMAT is equal to HE_MU
- 2 if the parameter FORMAT is equal to HE_EXT_SU

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- 3 if the parameter FORMAT is equal to HE_TRIG

— The Coding Type subfield is set to 0 if the parameter FEC_CODING is equal to BCC_CODING and set to 1 if equal to LDPC_CODING.

— The Tx BF subfield is set to 1 if the parameter BEAMFORMED is equal to 1 and set to 0 if equal to 0.

— The BW subfield shall indicate a bandwidth less than or equal to the bandwidth indicated by the parameter CH_BANDWIDTH.

— The RU subfield shall cooperate with the BW subfiled to indicate the RU at which the recommended HE-MCS locates. The recommeded RU shall be within an RU in which the measured HE PPDU is located.

When the MFB requester sets the MRQ subfield to 1 and sets the MSI subfield to a value that matches the MSI subfield value of a previous request for which the responder has not yet provided feedback, the responder shall discard or abandon the computation for the MRQ that corresponds to the previous use of that MSI subfield value and start a new computation based on the new request.

A STA may respond immediately to a current request for MFB with a frame containing an MSI field value and NSS, HE-MCS, and DCM subfields that correspond to a request that precedes the current request.

27.14 Power management

27.14.1 Intra-PPDU power save for non-AP HE STAs

Intra-PPDU power save is the power save mechanism for an HE STA to enter the doze state until the end of a received PPDU which is identified as an Intra-BSS frame by the below conditions listed in this subclause.

A non-AP HE STA that has dot11IntraPPDUPowerSaveOptionActivated equal to true operates in intra-PPDU power save mode.

A non-AP HE STA that is in intra-PPDU power save mode may enter the doze state until the end of a PPDU currently being received when one of the following conditions is met:

— The PPDU is an HE MU PPDU where the RXVECTOR parameter BSS_COLOR is the BSS color of the BSS with which the STA is associated, the RXVECTOR parameter UL_FLAG is 0 and the RXVECTOR parameter STA_ID_LIST does not include the identifier of the STA or the broadcast identifier(s) intended for the STA and the BSS Color Disabled subfield is 0 in the most recently received HE Operation element from the AP to which it is associated.

— The PPDU is an HE MU PPDU, HE SU PPDU or HE ER SU PPDU and one of the following conditions are true:

- The RXVECTOR parameter BSS_COLOR is the BSS color of the BSS with which the STA is associated, the RXVECTOR parameter UPLINK_FLAG is 1 and the BSS Color Disabled subfield is 0 in the most recently received HE Operation element from the AP to which it is associated .
- The RXVECTOR parameter BSS_COLOR is the BSS color of the BSS with which the STA is associated, the RXVECTOR parameter UL_FLAG is 0 and a PHY-RXEND.indication(UnsupportedRate) primitive was received and the BSS Color Disabled subfield is 0 in the most recently received HE Operation element from the AP to which it is associated.

— The PPDU is an HE TB PPDU where the RXVECTOR parameter BSS_COLOR is the BSS color of the BSS with which the STA is associated and the BSS Color Disabled subfield is 0 in the most recently received HE Operation element from the AP to which it is associated.

— The PPDU is a VHT PPDU where the RXVECTOR parameter PARTIAL_AID is the BSSID[39:47] of the BSS with which the STA is associated and the RXVECTOR parameter GROUP_ID is 0.

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— The PPDU is a PPDU with:
  - An A-MPDU including TA or RA equal to either the BSSID of the BSS with which the STA is associated or the BSSID of any BSS of a multiple BSSID set that the STA's associated BSS belongs to and,
  - The RA is not the individual MAC address of the STA or the group address(es) of the STA

— The PPDU is either an HE MU PPDU with the RXVECTOR parameter UL_FLAG set to 0 or a VHT MU PPDU containing an A-MPDU with
  - The RA(s) in the A-MPDU is(are) equal to the STA's individual address and,
  - The STA has received in the A-MPDU at least one MPDU delimeter with EOF equal to 1 and with MPDU length field equal to 0.

A non-AP HE STA that is in intra-PPDU power save mode and has entered doze state shall continue to operate its NAV timers and consider the medium busy during doze state and shall transition into awake state at the end of the PPDU.

A non-AP HE STA that is in intra-PPDU power save mode may discard a PPDU identified as an inter-BSS frame as defined in 27.2.1 (Intra-BSS and inter-BSS frame detection) until the end of the PPDU.

NOTE—The STA can contend for access to the medium immediately on the expiry of the NAV timers.

27.14.2 Power save with UORA

This subclause illustrates the power save mechanisms for UORA capable non-AP HE STAs that are operating in PS mode using the UORA procedure (see 27.5.5.2 (UORA procedure)).

An HE AP may indicate one or more start times for broadcast TWT SP containing Trigger frames with random access allocations in the broadcast TWT element that is included in the Beacon frame or a Management frame as described in 27.7.3.2 (Rules for TWT scheduling AP). An example of power save operation is shown in Figure 27-12 (Example of power save operation with UORA).

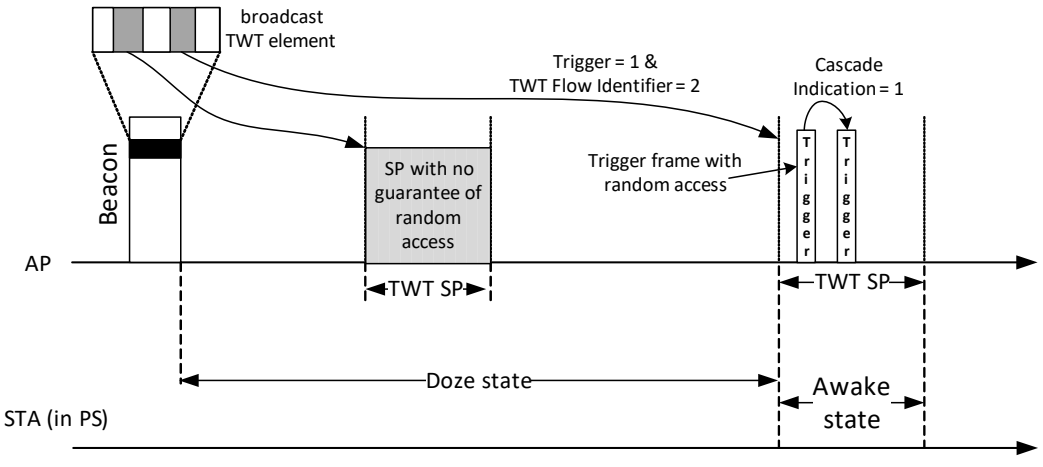


Figure 27-12—Example of power save operation with UORA

An associated HE STA that supports UORA procedure when operating in PS mode may enter the doze state after receiving a Management frame containing a TWT element with the Broadcast subfield equal to 1, Trigger subfield equal to 1, and a TWT Flow Identifier subfield equal to 2 and may transition to awake state at the start of that broadcast TWT SP as described in 27.7.3.3 (Rules for TWT scheduled STA) and shall fol-

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low the procedure defined in 27.5.5 (UL OFDMA-based random access (UORA)) when the AP includes one or more RUs with AID12 value equal to 0 in a Trigger frame transmitted during that broadcast TWT SP.

An unassociated HE STA that supports UORA procedure may after receiving a Beacon frame, a broadcast Probe Response frame or a FILS Discovery frame containing a TWT element with the Broadcast subfield equal to 1, Trigger subfield equal to 1, and TWT Flow Identifier subfield equal to 2, begin listening for Trigger frames at the start of that broadcast TWT SP as described in 27.7.3.3 (Rules for TWT scheduled STA) and shall follow the procedure defined in 27.5.5 (UL OFDMA-based random access (UORA)) when the AP includes one or more RUs with AID12 value equal to 2045 in a Trigger frame transmitted during that broadcast TWT SP.

An HE AP that transmits a Trigger frame shall set the Cascade Indication field in the frame as defined in 27.7.3.2 (Rules for TWT scheduling AP).

An HE STA shall follow the procedure described in 27.7.5 (PS operation during TWT SPs) to determine if TWT SP termination event has occurred and may enter doze state if no other condition requires the STA to remain awake. If AdjustedMinimumTWTWakeDuration time has elapsed from the scheduled TWT SP start time and no Trigger frames are transmitted by the AP, the HE STA may enter doze state if no other condition requires the STA to remain awake.

When the No Further RA RU subfield is set to 1, an AP shall not allocate the random access RUs assigned to 2045 in the subsequent Trigger frames until either the end of the current TWT SP or the end of the current TXOP in case of no TWT SP.

While TWT SP termination event has not occurred, an HE STA may use the value indicated in the Cascade Indication field in a Trigger frame to determine whether to enter the doze state. An HE STA shall decrement its OBO counter as defined in 27.5.5 (UL OFDMA-based random access (UORA)). If the OBO counter decrements to a nonzero value and the Cascade Indication field is equal to 0, then the STA may enter the doze state if no other condition requires it to remain awake. If the OBO counter decrements to a nonzero value and the Cascade Indication field is equal to 1, then the STA may remain awake for random access in the cascaded Trigger frame unless the No Further RA RU subfield is equal to 1 in User Info fields with AID12 subfield equal to 0 or 2045 in which case, the STA may enter the doze state immediately until either the end of the current TWT SP or the end of the current TXOP in case of no TWT SP if no other condition requires the STA to remain awake.If the OBO counter decrements to zero then the STA shall follow the procedure defined in 27.5.5.2 (UORA procedure) to transmit an HE TB PPDU in response to the Trigger frame.

27.14.3 Opportunistic power save

27.14.3.1 General

An OPS STA is a non-AP HE STA that sets the OPS Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element to 1.

An OPS AP is an AP HE STA that sets the OPS Support subfield in the HE MAC Capabilities Information field in HE Capabilities element to 1.

Opportunistic power save mechanism has the objective to allow OPS STAs to opportunistically go to doze state for a defined period. To achieve this, an OPS AP splits a beacon interval into several periodic broadcast TWT SPs and provides, at the beginning of each SP, the scheduling information for all OPS STAs. Based on this information, the OPS STAs may opportunistically go to doze state until the next TWT SP.

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27.14.3.2 AP operation for opportunistic power save

To enable opportunistic power save, an OPS AP shall include a TWT element in beacons to set a periodic Broadcast TWT SP with the following information:

— The TWT flow identifier field set to 3

— The Broadcast TWT ID subfield is set to 0

At the beginning of these periodic TWT SPs with the TWT Flow Identified field set to 3, the AP shall transmit a TIM frame or a FILS Discovery frame that includes a TIM element (see 9.4.2.6 (TIM element)). The AP should transmit a FILS Discovery frame instead of a TIM frame if the TWT SP start time aligns with the transmission time of a FILS Discovery frame. If the OPS AP also operates with TIM Broadcast and uses TIM frames for Opportunistic power save mechanism, the OPS AP should align the transmission time of a TIM frame for TIM Broadcast, with the target time of the BC TWT SP with the TWT flow identifier field set to 3.

27.14.3.3 STA operation for opportunistic power save

When an OPS STA with AID *N* receives a TIM element in TIM frame or FILS Discovery frame from the associated OPS AP within a broadcast TWT SP with the TWT Flow Identifier field set to 3, the STA may enter the doze state during the TWT SP and until the next TWT SP with the TWT flow identifier field set to 3, if the bit *N* in the traffic indication virtual bitmap field of the current TIM element is set to 0.

NOTE—The opportunistic power save protocol does not restrict the OPS STA's channel access. The OPS STA can always access the channel with EDCA.

27.15 PPDU format, BW, MCS, NSS, and DCM selection rules

27.15.1 General

An HE STA can transmit different PPDUs formats, with different transmit parameters, such as channel width, MCS, NSS, DCM. This subclause defines the rules followed by an HE STA for selecting these parameters depending on the capabilities of the intended receiver(s) and other considerations.

27.15.2 PPDU format selection

An HE STA that transmits non-HT, HT, or VHT PPDUs shall follow the rules defined in 10.7 (Multirate support). An HE STA may transmit an HE SU PPDU to a peer HE STA.

A STA may transmit a Control frame in a non-HT PPDU. A first STA shall not transmit a Control frame in an HE ER SU PPDU to a second STA unless the second STA indicates the reception of HE ER SU PPDU.

An HE AP transmits HE MU PPDUs as defined in 27.5.1 (HE DL MU operation). A non-AP HE STA transmits HE TB PPDUs as defined in 27.5.3 (UL MU operation).

An HE STA may transmit a 242-tone HE ER SU PPDU to a peer HE STA if it has received from the peer STA an HE Capabilities element with the DCM Rx field greater than 0 or with the Partial Bandwidth Extended Range field equal to 1; otherwise the STA shall not transmit a 242-tone HE ER SU PPDU to the peer STA. An HE STA may transmit a 106-tone HE ER SU PPDU to a peer STA if it has received from the peer STA an HE Capabilities element with the Partial Bandwidth Extended Range field equal to 1; otherwise the STA shall not transmit a 106-tone HE ER SU PPDU to the peer STA.

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A non-AP HE STA shall not transmit an HE MU PPDU to a peer STA unless it has received from the peer STA an HE Capabilities element with the Rx HE MU PPDU From Non-AP STA subfield in the HE PHY Capabilities Information field equal to 1.

NOTE—A non-AP STA transmitting an HE MU PPDU sets the TXVECTOR parameter UPLINK_FLAG to 1 (see 27.11.2 (UPLINK_FLAG)). The UL MU PPDU format enables the non-AP STA to include its AID (i.e., transmitter's AID) in the PHY header of the PPDU and its use is out of scope of the standard.

An HE STA shall send Control frames following the rules defined in 10.7.6 (Rate selection for Control frames)) with the following exceptions:

— A Control frame sent in response to an HE ER SU PPDU or HE SU PPDU that uses STBC shall be carried in the same PPDU format as the soliciting PPDU.

— A Control frame sent by the AP as a response to an HE TB PPDU may be carried in any PPDU format that is supported by the intended receiver(s).

— A Trigger frame that is not an MU RTS Trigger frame may be carried in any PPDU format that is supported by the intended receiver(s).

— A Control frame sent as a response to a PPDU, containing a Trigger frame that is not an MU-RTS Trigger frame or a frame containing a UMRS Control field, is carried in an HE TB PPDU (see 27.5.3 (UL MU operation)).

— An Ack frame sent as a response to an HE ER SU PPDU or HE SU PPDU containing an FTM frame shall be sent in the same PPDU format as the soliciting PPDU except when the FTM frame is carried in HE SU PPDU and the most recent successfully received PPDU sent by the responding STA to the soliciting STA after association was an HE ER SU PPDU in which case the Control frame shall be carried in HE ER SU PPDU.

— If a Control frame is sent as a response to a soliciting HE ER SU PPDU the frame shall be carried in an HE ER SU PPDU except when the most recent successfully received PPDU sent by the responding STA to the soliciting STA after association was not an HE ER SU PPDU in which case the Control frame shall be carried in non-HT PPDU.

— If the Control frame is sent as a response to a soliciting HE SU PPDU then the frame shall be carried in a non-HT PPDU except when the most recent successfully received PPDU sent by the responding STA to the soliciting STA after association was an HE ER SU PPDU in which case the Control frame shall be carried in an HE ER SU PPDU.

NOTE—PPDU format switching between non-HT and ER SU PPDU occurs in subsequent TXOPs. A STA that solicits a Control frame from a responding STA accounts for the PPDU format of the Control frame to calculate the expected duration of the TXOP. The responding STA determines that the most recent PPDU sent to the soliciting STA is successfully received if it receives an immediate acknowledgment by the soliciting STA in response to the PPDU.

27.15.3 MCS, NSS, BW and DCM selection

An HE STA shall follow the rules defined in 10.7 (Multirate support) and 27.15.4 (Rate selection constraints for HE STAs) for selecting the rate, MCS, NSS, and the rules defined in 10.3.2.6 (VHT RTS procedure), 10.3.2.7 (CTS and DMG CTS procedure), 10.7.6.6 (Channel Width selection for Control frames) and 10.7.11 (Channel Width in non-HT and non-HT duplicate PPDUs) for selecting the channel width (BW) of transmitted PPDUs with the following exceptions:

— MCS, NSS, and BW selection for an HE TB PPDU are defined in 27.5.3.3 (STA behavior for UL MU operation).

— Rate and BW selection for a CTS sent in response to MU RTS are defined in 27.2.5 (MU-RTS/CTS procedure)

— MCS, and NSS for a Control frame sent in response to an HE ER SU PPDU shall be <MCS0, 1> when the Control frame is carried in an HE ER SU PPDU and the data rate is 6 Mb/s when the Control frame is carried in a non-HT PPDU (see 10.7.6.5 (Rate selection for control response frames)).

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— NSS and BW selection is further constrained as defined in 27.8 (Operating mode indication), 11.42 (Notification of operating mode changes) and 27.15.2 (PPDU format selection).

An HE STA that transmits an HE PPDU shall use an <HE-MCS, NSS> tuple supported by the receiver STA. An <HE-MCS, NSS> tuple is supported if reported as such in the Supported HE-MCS and NSS Set field in the HE Capabilities element received from that STA. When the Supported HE-MCS and NSS set of the receiving STA or STAs is not known, the transmitting STA shall transmit using a <HE-MCS, NSS> tuple in the basic HE-MCS and NSS set if the basic HE-MCS and NSS set is not empty, otherwise the transmitting STA shall transmit using a <HE-MCS, NSS> tuple in the mandatory HE-MCS and NSS Set. An HE STA is subject to all of the rules for HT STAs and VHT STAs that apply to its operating band (see 10.26 (Protection mechanisms)).

An HE STA that sends a Control frame in response to a frame carried in an HE SU PPDU or an HE ER SU PPDU or an HE MU PPDU that carries an MPDU with the Ack Policy equal to Normal Ack or Implicit Block Ack Request shall set the TXVECTOR parameter CH_BANDWIDTH to indicate a channel width that is the same as the channel width indicated by the RXVECTOR parameter CH_BANDWIDTH of the frame eliciting the response. When the most recent successfully received PPDU sent by the responding STA to the soliciting STA after association was an HE ER SU PPDU, the soliciting STA that sends an HE SU PPDU shall set the TXVECTOR parameter CH_BANDWIDTH to CBW20.

If a control response frame is to be transmitted within an HE SU PPDU, HE MU PPDU, the channel width (CH_BANDWIDTH parameter of the TXVECTOR) shall be selected first according to 10.7.6.6 (Channel Width selection for Control frames), and then the <HE-MCS, NSS> tuple shall be selected from a set of <HE-MCS, NSS> tuples called the *CandidateMCSSet*. The *CandidateMCSSet* is defined in 10.7.6.5.3 (Control response frame MCS computation) except that the set additionally contains the <HE-MCS, NSS> tuples for an HE STA.

An HE STA may transmit an HE PPDU with DCM to a peer STA if it has received from the peer STA an HE Capabilities element with the DCM Rx subfield in the HE PHY Capabilities Information field greater than 0; otherwise the STA shall not transmit an HE PPDU with DCM to the peer STA. An HE STA transmits an HE TB PPDU with DCM as defined in 27.5.3.3 (STA behavior for UL MU operation). When sending a Trigger Frame, the HE AP shall not set the DCM subfield of User Info field in the Trigger Frame to 1 if the destination HE non-AP STA sets the DCM Max Constellation Tx field to 0 in the HE PHY Capabilities Information field.

An HE STA that sends a Control frame in an HE ER SU PPDU format shall use:

— DCM encoding if the most recent successfully received PPDU sent by the HE STA to the soliciting STA after association used DCM; otherwise the STA shall not use DCM for the Control frame.

— 106-tone HE ER SU PPDU if the most recent successfully received PPDU sent by the HE STA to the soliciting STA after association was a 106-tone HE ER SU PPDU; otherwise the STA shall not use a 106-tone HE ER SU PPDU for the Control frame.

NOTE—TX parameter switching occurs in subsequent TXOPs. A STA that solicits a Control frame from a peer STA accounts for the TX parameter of the Control frame to calculate the expected duration of the TXOP. The responding STA determines that the most recent PPDU sent to the soliciting STA is successfully received if it receives an immediate acknowledgment by the soliciting STA in response to the PPDU.

27.15.4 Rate selection constraints for HE STAs

27.15.4.1 Rx Supported HE-MCS and NSS Set

The Rx supported HE-MCS and NSS set of a first HE STA is determined by a second HE STA for each <HE-MCS, NSS> tuple NSS = 1, …, 8 and bandwidth (≤ 80 MHz, and 160 MHz or 80+80 MHz) from the

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Supported HE-MCS And NSS Set field of the HE Capabilities element received from the first STA as follows:

— If support for the HE-MCS for NSS spatial streams at that bandwidth is mandatory (see 28.5 (Parameters for HE-MCSs)), then the <HE-MCS, NSS> tuple at that bandwidth is supported by the first STA on receive.

— Otherwise, if the Max HE-MCS For *n* SS subfield (*n* = NSS) in each Rx HE-MCS Map For *b* subfield for $b \in \{\leq 80$ MHz, 160 MHz, 80+80 MHz$\}$ indicates support and neither the Operating Mode field nor the OM Control subfield is received from the first HE STA, then the <HE-MCS, NSS> tuple at that bandwidth is supported by the first STA on receive as defined in 9.4.2.237.4 (Supported HE-MCS And NSS Set field).

— Otherwise,

- If the Operating Mode field is received from the first HE STA, the <HE-MCS, NSS> tuple at that bandwidth is supported by the first STA on receive as defined 9.4.2.237.4 (Supported HE-MCS And NSS Set field) and by Equation (9-ax2).
- If the OM Control subfield is received from the first HE STA, The <HE-MCS, NSS> tuple at that bandwidth is supported by the first STA on receive as defined 9.4.2.237.4 (Supported HE-MCS And NSS Set field) and by Equation (9-ax2).

— Otherwise, the <HE-MCS, NSS> tuple at that bandwidth is not supported by the first STA on receive.

The <HE-MCS, NSS> tuples excluded by 27.15.4.3 (Additional rate selection constraints for HE PPDUs) can also be eliminated from the Rx supported HE-MCS and NSS set.

An HE STA shall not, unless explicitly stated otherwise, transmit an HE PPDU unless the <HE-MCS, NSS> tuple and bandwidth used are in the Rx supported HE-MCS and NSS set of the receiving STA(s).

27.15.4.2 Tx Supported HE-MCS and NSS Set

The Tx supported HE-MCS and NSS set of a first HE STA is determined by a second STA for each <HE-MCS, NSS> tuple NSS = 1, …, 8 and bandwidth (≤ 80 MHz, and 160 MHz or 80+80 MHz) from the Supported HE-MCS And NSS Set field received from the first STA as follows:

— If support for the <HE-MCS, NSS> tuple at that bandwidth is mandatory (see 28.5 (Parameters for HE-MCSs)), then the <HE-MCS, NSS> tuple at that bandwidth is supported by the first STA on transmit.

— Otherwise, if the Max HE-MCS For *n* SS subfield (*n* = NSS) in each Tx HE-MCS Map For *b* subfield for $b \in \{\leq 80$ MHz, 160 MHz, 80+80 MHz$\}$ indicates support, then the <HE-MCS, NSS> tuple at that bandwidth is supported by the first STA on transmit as defined in 9.4.2.237.4 (Supported HE-MCS And NSS Set field).

— Otherwise, the <HE-MCS, NSS> tuple at that bandwidth is not supported by the first STA on transmit.

27.15.4.3 Additional rate selection constraints for HE PPDUs

The following apply for a STA that transmits an HE PPDU with a number of spatial streams (NSS) less than or equal to 8:

— If the channel width of the PPDU is equal to CBW20 or CBW40, then the STA shall not use a <HE-MCS, NSS> tuple if the HE-MCS is equal to 0, 1, 2, or 3 and the HT MCS with value VHT MCS + 8×(NSS – 1) is marked as unsupported in the Rx MCS bitmask of the HT capabilities element of the receiver STA.

— If the channel width of the PPDU is equal to CBW80, CBW160, or CBW80+80, then the STA shall not use a <HE-MCS, NSS> tuple if the HE-MCS is equal to 0 or 1 and both the HT MCS values

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2 × HE-MCS + 8 × (NSS – 1) and 2 × (HE-MCS + 1) + 8 × (NSS – 1) are marked as unsupported in the Rx MCS bitmask of the HT Capabilities element of the receiver STA.

An example tabulation of this behavior is given in Table 27-9 (Example of rate selection for HE PPDUs).

Table 27-9—Example of rate selection for HE PPDUs

HT MCSs that are marked as unsupported	<HE-MCS, NSS> tuples that are not used for CBW20 and CBW40	<HE-MCS, NSS> tuples that are not used for CBW80, CBW160, and CBW80+80
0, 8, 16	<0, 1>, <0, 2>, <0, 3>	-
1, 9	<1, 1>, <1, 2>	-
10	<2, 2>	-
3	<3, 1>	-
0, 1	<0, 1>, <1, 1>	<0, 1>
2, 3	<2, 1>, <3, 1>	<1, 1>
0, 1, 8, 9	<0, 1>, <1, 1>, <0, 2>, <1, 2>	<0, 1>, <0, 2>

27.15.4.4 Rx Supported VHT-MCS and NSS Set

For each <VHT-MCS, NSS> tuple, NSS = 1, …, 8, and bandwidth (20 MHz, 40 MHz, 80 MHz, and 160 MHz or 80+80 MHz) from the Supported VHT-MCS and NSS Set field received from a first STA, a second HE STA shall follow the rules in subclause 10.7.12.1 (Rx Supported VHT-MCS and NSS Set) to determine the Rx Supported VHT-MCS and NSS Set of the first HE STA with the following exception:

— If the second HE STA receives OM Control subfield from the first HE STA, the Rx Supported HE-MCS and NSS Set of a first HE STA is determined by a second HE STA according to 9.4.2.158.3 (Supported VHT-MCS and NSS Set field) and Table 9-18b (Setting of the VHT Channel Width and VHT NSS at a HE STA transmitting the OM Control subfield).

NOTE—When the second STA receives both an Operating Mode field and an OM Control subfield from the first STA, the rules in 27.8.1 (General) apply.

27.16 HE BSS operation

27.16.1 Basic HE BSS functionality

An HE STA has dot11HEOptionImplemented equal to true.

A STA that is starting an HE BSS shall be able to receive and transmit at each of the <HE-MCS, NSS> tuple values indicated by the Basic HE-MCS And NSS Set field of the HE Operation parameter of the MLME-START.request primitive and shall be able to receive at each of the <HE-MCS, NSS> tuple values indicated by the Supported HE-MCS and NSS Set field of the HE Capabilities parameter of the MLME-START.request primitive. The basic HE-MCS and NSS set is the set of <HE-MCS, NSS> tuples that are supported by all HE STAs that are members of an HE BSS. It is established by the STA that starts the HE BSS, indicated by the Basic HE-MCS And NSS Set field of the HE Operation parameter in the MLME-START.request primitive. Other HE STAs determine the basic HE-MCS and NSS set from the Basic HE-

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MCS And NSS Set field of the HE Operation element in the BSSDescription derived through the scan mechanism (see 11.1.4.1 (General)).

An HE STA shall not attempt to join (MLME-JOIN.request primitive) a BSS unless it supports (i.e., is able to both transmit and receive using) all of the <HE-MCS, NSS> tuples in the basic HE-MCS and NSS set.

NOTE—An HE STA does not attempt to (re)associate with an HE AP unless the STA supports (i.e., is able to both transmit and receive using) all of the <HE-MCS, NSS> tuples in the Basic HE-MCS And NSS Set field in the HE Operation element transmitted by the AP because the MLME-JOIN.request primitive is a necessary precursor to (re)association.

A STA that sets dot11HEOptionImplemented to true shall set dot11HighThroughputOptionImplemented to true when operating in the 2.4 GHz band. A STA that sets dot11HEOptionImplemented to true shall set dot11VeryHighThroughputOptionImplemented and dot11HighThroughputOptionImplemented to true when operating in the 5 GHz band. A non-AP STA that sets dot11HEOptionImplemented to true shall set dot11MultiBSSIDImplemented to true.

A STA that is an HE AP or an HE mesh STA declares its channel width capability in the HE Capabilities element as described in Table 9-262aa (Subfields of the HE PHY Capabilities Information field). If the STA is an HE AP then it shall indicate support for at least 80 MHz channel width if it operates in 5 GHz; otherwise it may indicate any channel width support.

A STA transmitting an HT Capabilities element and HE Capabilities element shall set the Supported Channel Width Set subfield of the HT Capabilities element to 1 when either B0 or B1 of the Channel Width Set subfield of the HE Capabilities element is 1, except when the STA is a 20 MHz-only non-AP HE STA in which case the Supported Channel Width Set subfield of the HT Capabilities element is 0. STA transmitting a VHT Capabilities element and HE Capabilities element shall set the Supported Channel Width Set subfield of the VHT Capabilities element to a value that indicates the same channel width capability as the channel width capability indicated in the HE Capabilities element, except when the STA is a 20 MHz-only non-AP HE STA in which case the Supported Channel Width Set subfield of the VHT Capabilities element is reserved.

At a minimum, an HE STA sets the Rx MCS Bitmask subfield of the Supported MCS Set field of its HT Capabilities element according to the setting of each Rx HE-MCS Map For b subfield, $b \in \{\leq 80$ MHz, 160 MHz, 80+80 MHz$\}$, of the Supported HE-MCS And NSS Set field of its HE Capabilities element as follows: for each Max HE-MCS For n SS subfield, $1 \leq n \leq 4$, of each Rx HE-MCS Map For b subfield, $b \in \{\leq 80$ MHz, 160 MHz, 80+80 MHz$\}$, with a value other than 3 (no support for that number of spatial streams), the STA shall indicate support for MCSs $8(n-1)$ to $8(n-1)+7$ in the Rx MCS Bitmask subfield, where n is the number of spatial streams, except for those MCSs marked as unsupported as described in 27.15.4.3 (Additional rate selection constraints for HE PPDUs).

An HE AP or an HE mesh STA shall set the VHT Operation Information Present field in the HE Operation element to 0 if dot11VeryHighThroughputOptionImplemented is false or a VHT Operation element is present in the frame that carries the HE Operation element. Otherwise, the HE AP or the HE mesh STA shall set the VHT Operation Information Present field in the HE Operation element to 1.

A STA that is an HE AP or an HE mesh STA that transmits an HE Operation element that has the VHT Operation Information Present field set to 1 shall set the STA Channel Width subfield in the HT Operation element HT Operation Information field, the Channel Width, Channel Center Frequency Segment 0 and Channel Center Frequency Segment 1 subfields in the HE Operation element VHT Operation Information field to indicate the BSS bandwidth as defined in Table 11-24 (VHT BSS bandwidth).

The setting of the Channel Center Frequency Segment 0, Channel Center Frequency Segment 1 and Channel Center Frequency Segment 2 subfields is shown in Table 11-25 (Setting of Channel Center Frequency Segment 0, Channel Center Frequency Segment 1 and Channel Center Frequency Segment 2 subfields), except

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that the Max NSS support is provided by the HE STA in frames that contain an HE Capabilities element (see 9.4.2.237 (HE Capabilities element)) and an Operating Mode field (see 9.2.4.6.4.3 (Operating Mode) and 9.4.1.53 (Operating Mode field)), wherein in the table the Max NSS support refers to the HE Max NSS support instead of the VHT Max NSS support for an HE STA.

An HE STA shall determine the channelization using the information in the Primary Channel field of the HT Operation element when operating in 2.4 GHz and the combination of the information in the Primary Channel field in the HT Operation element and the Channel Center Frequency Segment 0 and Channel Center Frequency Segment 1 subfields in the VHT Operation Information field in the VHT Operation element when operating in 5 GHz (see 21.3.14 (Channelization)).

An HE AP or an HE mesh STA shall set the Secondary Channel Offset subfield in the HT Operation Information field in the HT Operation element to indicate the secondary 20 MHz channel as defined in Table 9-168 (HT Operation element fields and subfields), if the BSS bandwidth is more than 20 MHz.

An HE STA that is a member of an HE BSS shall follow the same rules that are defined in 11.40.1 (Basic VHT BSS functionality) when transmitting a 20 MHz, 40 MHz, 80 MHz, 160 MHz or 80+80 MHz HE PPDUs with the following exceptions:

— An HE TB PPDU sent in response to a Trigger frame or a frame with a UMRS Control field follows the rules defined in 27.5.3.3 (STA behavior for UL MU operation).

— An 80 MHz, 160 MHz or 80+80 MHz DL HE MU PPDU with preamble puncturing may be transmitted if either the primary 20 MHz or the primary 40 MHz, or both are occupied by the transmission (see Table 28-19 (HE-SIG-A field of an HE MU PPDU)).

An HE STA shall not transmit to a second HE STA using a bandwidth that is not indicated as supported in the Channel Width Set subfield in the HE Capabilities element received from that HE STA.

An HE STA shall not transmit an MPDU in an HE PPDU to a STA that exceeds the maximum MPDU length capability indicated in the VHT Capabilities element received from the recipient STA or that exceeds the Maximum A-MSDU Length in the HT Capabilities element received from the recipient STA.

An HE STA shall not transmit an A-MPDU in an HE PPDU to a STA that exceeds the maximum A-MPDU length capability indicated in the HE Capabilities, VHT Capabilities, and HT Capabilities element received from the recipient STA. The maximum A-MPDU length capability is obtained as a combination of the Maximum A-MPDU Length Exponent subfields in the HE Capabilities and VHT Capabilities element if the recipient STA has transmitted the VHT Capabilities; otherwise it is obtained from a combination of the Maximum A-MPDU Length Exponent subfields in the HE Capabilities and the HT Capabilities element.

An HE AP shall set the RIFS Mode field in the HT Operation element to 0.

An HE STA shall follow the rules defined in 11.40 (VHT BSS operation) for channel selection, determining scanning requirements, channel switching, NAV assertion and antenna indication when operating in 5 GHz unless explicitly stated otherwise in Clause 27.

An HE STA shall follow the rules defined in 11.16 (20/40 MHz BSS operation) for channel selection, determining scanning requirements, channel switching, NAV assertion when operating in 2.4 GHz unless explicitly stated otherwise in Clause 27.

An HE AP corresponding to the ER BSS shall not respond to the Probe Request or (Re)Association Request frames sent from a non-HT STA, or an HE STA that does not support Partial Band Extended Range capability if the HE AP transmits ER Beacon in HE_ER_SU PPDU with 106-tone RU.

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A STA shall have the same value of maximum VHT NSS defined by its Rx HE-MCS Map For ≤ 80 MHz field in the HE Capabilities element as the maximum NSS value indicated by its Rx VHT-MCS Map field in the VHT Capabilities element. If a STA supports 160 MHz, the Maximum NSS defined by its Rx VHT-MCS Map field and Extended NSS BW Support field in the VHT Capabilities element at 160 MHz shall not be more than the maximum NSS defined by its Rx HE-MCS Map For 160 MHz field in the HE Capabilities element at 160 MHz. If a STA supports 80+80 MHz, the maximum NSS defined by its Rx VHT-MCS Map field and Extended NSS BW Support field in the VHT Capabilities element at 80+80 MHz shall not be more than the maximum NSS defined by its Rx HE-MCS Map For 80+80 MHz field in the HE Capabilities element at 80+80 MHz. For every NSS in VHT Capabilities elements and HE Capabilities elements transmitted by a STA, if the maximum HE-MCS is 9 or more, the maximal VHT-MCS shall be 9. Otherwise the maximal VHT-MCS shall be the same as the HE-MCS. A HE STA shall not transmit a VHT Capabilities element with the Supported Channel Width Set field equal to 1 and the Extended NSS BW Support field equal to 3 or with the Supported Channel Width Set field equal to 2 and the Extended NSS BW Support field equal to 3.

If a HE STA supports 160 MHz, the maximum NSS defined by its Rx HE-MCS Map field for an HE-MCS in the HE Capabilities element at 160 MHz shall not be more than the maximum NSS defined by its Rx HE-MCS Map field for the HE-MCS in the HE Capabilities element at 80 MHz.

If an HE STA supports 80+80 MHz, the maximum NSS defined by its Rx HE-MCS Map field for a HE-MCS in the HE Capabilities element at 80+80 MHz shall not be more than the maximum NSS defined by its Rx HE-MCS Map field for the HE-MCS in the HE Capabilities element at 80 MHz.

27.16.2 BSS color

27.16.2.1 Selecting and advertising a new BSS color

An HE AP that sets up a BSS selects a BSS color as defined in 27.11.4 (BSS_COLOR). An HE AP may change the BSS color under certain conditions such as when it detects an OBSS using the same BSS color. The conditions for changing the BSS color and the method for selecting a new BSS color are beyond the scope of this standard.

An HE AP shall announce its decision to change the BSS color via the BSS Color Change Announcement element which is carried in the Beacon, Probe Response and (Re)Association Response frames. The AP may also advertise the BSS color change event via the HE BSS Color Change Announcement frame. The BSS color change announcement should be advertised for a period of time that is sufficient for all STAs in the BSS, including STAs in power save mode, to have the opportunity to receive at least one BSS Color Change Announcement element before the BSS color change occurs.

If the Color Switch Countdown field in BSS Color Change Announcement element has a value greater than 0, then at the next TBTT its value is decremented by 1 until it reaches 0. BSS color change TBTT is the one at which the Color Switch Countdown field value has decremented to 0. An HE AP shall not alter the BSS color change TBTT after it has begun advertising an upcoming BSS color change.

During the time leading up to the BSS color change TBTT:

— An HE AP shall set the BSS Color Disabled subfield to 1 and shall continue to advertise the existing BSS color via the BSS Color subfield in the HE Operation element.

— An HE AP shall not change the value it advertises in the New BSS Color subfield of the BSS Color Change Announcement element.

— An HE AP shall set the TXVECTOR parameter BSS_COLOR of an HE PPDU to the existing BSS Color.

At the BSS color change TBTT, an HE AP shall:

— Set to 0 the BSS Color Disabled subfield in the HE Operation element that it transmits

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— Start advertising the new BSS color in the BSS Color subfield in the HE Operation element
— Start using the new BSS color for all frames that it transmits after the TBTT

A non-AP HE STA that receives a BSS Color Change Announcement element shall start using the BSS Color specified in the received BSS Color Change Announcement element subsequent to the BSS Color change TBTT.

A non-AP HE STA in an infrastructure BSS shall not transmit the BSS Color Change Announcement element.

27.16.2.2 Detecting and reporting BSS color collision

27.16.2.2.1 General

An HE AP may determine that a BSS color collision has occurred if it receives frames from an OBSS STA containing the same BSS color as the one it has selected for its BSS or if it receives autonomous BSS color collision report(s) from its associated STA(s). The HE AP shall set the BSS Color Disabled subfield to 1 in the HE Operation element that it transmits if the BSS color collision persists for a duration of at least dot11BSSColorCollisionAPPeriod. An HE AP that decides to change its BSS color may consider BSS color information of OBSS APs that it has gathered by itself and via the autonomous collision report(s) from associated STA(s) when selecting the value of its BSS color.

27.16.2.2.2 Autonomous reporting of BSS color collision

A non-AP HE STA may autonomously report BSS color collision when it detects frames from OBSS STAs containing the same BSS color as the one advertised by the AP it is associated with. A STA whose dot11AutonomousBSSColorCollisionReportingImplemented is true shall support autonomous reporting of BSS color collision.

NOTE—All APs that are members of a multiple BSSID set use the same BSS color (see 27.11.4 (BSS_COLOR)). A non-AP HE STA should filter such BSSs while determining if there is a BSS color collision.

The HE STA's autonomous report shall include BSS color information of all OBSSs that the STA is able to detect frames from in order to help its associated AP select a new non-overlapping BSS color when the AP decides to switch to a different BSS color.

A non-AP HE STA that is autonomously reporting a BSS color collision, shall transmit an Event Report frame (see 9.6.14.3 (Event Report frame format)) containing a single Event Report element (see 9.4.2.68 (Event Report element)). The Event Report element shall carry Event Token field value set to 0 (autonomous report) and Event Type field value set to 4 (BSS Color Collision). The Event Report Status field shall be set to 0 (Successful) and the Event Report field shall carry information about the BSS color used by OBSSs that the reporting STA is able to detect.

A non-AP HE STA that intends to autonomously report a BSS color collision to its associated HE AP, shall do so by scheduling for transmission a BSS color collision Event Report frame every dot11BSSColorCollisionSTAPeriod unless the BSS color collision no longer exists or if the associated HE AP has set the BSS Color Disabled bit to 1 in HE Operation element that it transmits or if the non-AP STA has transmitted several such reports to its associated HE AP.

NOTE—The maximum number of BSS color collision reports a non-AP STA transmits is out of scope of this standard.

27.16.3 AID assignment

If the value of Partial BSS Color field is set to 1, then the HE AP shall allocate AIDs according to the formula for AID (5: 8)

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$$AID(5:8) = bin[(BCB(0:3) - (BSSID(44:47) \oplus BSSID(40:43))) \bmod 2^4, 4]$$

where *BCB*(0:3) are the 4 LSBs of the BSS color and *bin*[x, 4] is the operator that casts decimal value *x* into 4 bits binary vector.

27.16.4 Quiet HE STAs in an HE BSS

27.16.4.1 General

The QTP (Quiet time period) is an optional feature that defines a period for peer-to-peer operation during which only HE STA which supports the peer-to-peer operation may transmit frames. During the period an HE STA should not transmit frames unless it participates in peer-to-peer operation. All HE STAs in the HE BSS not participating peer-to-peer operation should stay quiet in the period. All HE STAs in the HE BSS not participating peer-to-peer operation may access the channel by following the CCA rule if it has high priority traffic to send.

An AP that supports QTP shall set the QTP Support field in the AP's HE Capabilities element to 1 and shall set the QTP Capability field to 0 otherwise. An HE STA decides to stay quiet pause its countdown counter and resume count down when a quiet period ends. An STA can continue the countdown if choose not to be silent.

27.16.4.2 Procedure at the requester HE STA

Upon the reception of an MLME-QTP.request primitive, an HE STA shall perform the following procedure to start the quiet time period operation (Figure 27-13 (Quiet time period operation)):

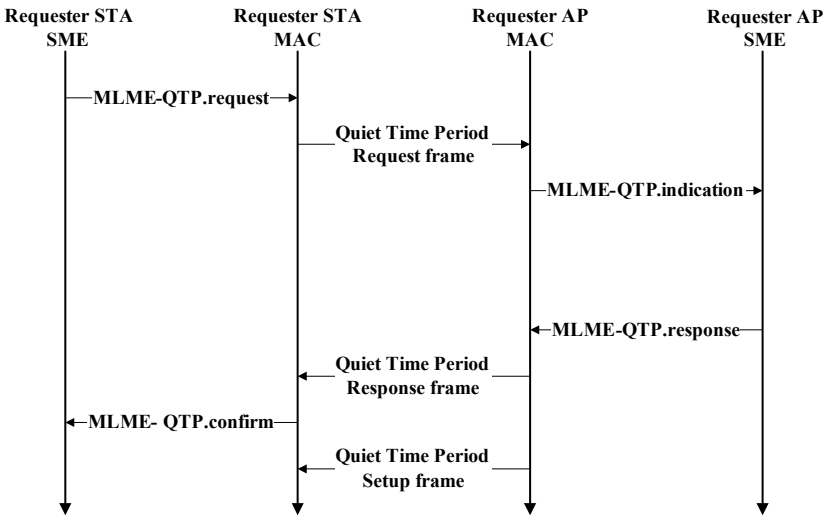


Figure 27-13—Quiet time period operation

a) If the responder AP and the requester HE STA are QTP capable as indicated by the QTP Support field in the HE Capabilities element, the requester HE STA sends a Quiet Time Period Request frame indicating the duration, interval, and type of operation (indicated by Service Specific Identifier). The requester HE STA may include multiple Quiet Time Period Request elements in one frame for multiple types of peer-to-peer operations.

b) If a Quiet Time Period Response frame is received with the dialog token matching the request token with a status code set to a value of SUCCESS, the AP has confirmed the reception of the Quiet Time

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Period Request element, and the MLME shall issue an MLME-QTP.confirm primitive indicating the success of the procedure.

c) When a Quiet Time Period Setup frame is received, the requester HE STA may transmit frames. The transmission of a frame by HE STA in this period shall follow the CCA rules.

NOTE 1—The HE STA can use the GAS protocol to transport an element that informs an AP about the type(s) of peer-to-peer operations that the HE STA supports.

NOTE 2—The frames belong to the requested type of peer-to-peer operation indicated by the vendor specific service identifier of the Quiet Time Period Response.

27.16.4.3 Procedure at the responder AP

A responder AP may operate as follows (Figure 27-13 (Quiet time period operation)):

a) When a QTP Request frame is received from an HE STA, the MLME shall issue an MLME-QTP.indication primitive.

b) Upon receipt of the MLME-QTP.response primitive, the AP may respond by sending Quiet Time Period Response frame.

   1) If the status code is SUCCESS, the request is accepted. The responder AP shall schedule the quiet period(s) according to the accepted request. Contained in the transmitted Quiet Time Period Response frame is a copy of the request token from the requester HE STA. The QTP procedure shall be terminated if the number of quiet periods exceeds the value of the Repetition Count field specified.

   2) If the status code is REJECTED, the AP indicated the request can not be fulfilled.

   3) If the status code is Countered, the AP counters the request with recommended values and the current request is rejected. Upon receiving the Countered, an HE STA shall send a new the Quiet Time request frame to set up the quiet time period.

c) When the scheduled quiet time periods arrive, the responder AP may transmit a Quiet Time Period Setup frame including Quiet Time Period Setup element. Only HE STA which supports the operation indicated by the Vendor Specific Service Identifier field of the Quiet Time Period Setup element may transmit frames in the quiet time period. The responder AP shall set the Quiet Period Duration field of Quiet Time Period Setup frame to a value no larger than indicated in Quiet Period Duration field of the Quiet Time Period Request element sent by the requester HE STA.

NOTE—AP is not required to transmit Quiet Time Period Setup frame when a scheduled quiet time periods arrives. The interference mitigation protocol is to provide an AP a tool to mitigate interference. How or whether AP will transmit Quiet Time Period Setup frame when a scheduled quiet time periods arrives is not in the scope of this specification.

27.16.5 ER beacon generation in an ER BSS

An ER Beacon frame is a Beacon frame carried in HE ER SU PPDU (242-tone RU or high frequency 106-tone RU in P20) format to provide additional link budget of downlink transmission to compensate the link budget imbalance between downlink and uplink due to introduction of UL OFDMA transmission. An HE AP may operate an ER BSS in addition to a non-HT BSS. An ER BSS, when present, shall operate independent of the non-HT BSS and shall have a BSSID different from the non-HT BSS operated by the AP. An ER BSS may have larger coverage area.

An HE AP may transmit ER Beacon frames and group addressed traffic defined in 10.7.5.8 (Rate selection for ER Beacon frames and group addressed frames). An HE AP may use larger CP length of HE_ER_SU PPDU to further improve the transmission reliability of ER Beacon frames.

Protection of transmission in ER BSS is out of scope of this specification.

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27.17 HE STA in non-HE BSS

When associated with a VHT AP, a 20 MHz-only non-AP HE STA shall set the Supported Channel Width Set subfield in its HT Capabilities element HT Capability Information field to 1, indicating that both 20 MHz operation and 40 MHz operation are supported. Otherwise 20 MHz-only non-AP HE STA shall set the Supported Channel Width Set subfield in its HT Capabilities element HT Capability Information field to 0, indicating that only 20 MHz operation is supported.

When transmitting a (Re)Association Request frame to a VHT AP, a 20 MHz-only non-AP HE STA shall include the Operating Mode Notification element with the Channel width subfield being 0 in the (Re-)Association Request frame to indicate 20 MHz operating channel width.

NOTE—After associated with a VHT AP, a 20 MHz-only non-AP HE STA can transmit an Operating Mode Notification frame with the Channel Bandwidth subfield being 0 to indicate 20 MHz operating channel width. With this, a VHT AP which ignores the Operating Mode Notification element in (Re)Association Request can use correct channel width for the transmission to a 20 MHz-only non-AP HE STA.

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28. High Efficiency (HE) PHY specification

28.1 Introduction

28.1.1 Introduction to the HE PHY

Clause 28 (High Efficiency (HE) PHY specification) specifies the PHY entity for a high efficiency (HE) orthogonal frequency division multiplexing (OFDM) system. In addition to the requirements in Clause 28 (High Efficiency (HE) PHY specification), an HE STA shall be capable of transmitting and receiving PPDUs that are compliant with the mandatory requirements of the following PHY specifications:

— Clause 19 (High Throughput (HT) PHY specification) and Clause 21 (Very High Throughput (VHT) PHY specification) if the HE STA supports an operating channel width greater than or equal to 80 MHz and is operating in the 5 GHz band

— Clause 19 (High Throughput (HT) PHY specification) and Clause 21 (Very High Throughput (VHT) PHY specification) transmission and reception on 20 MHz channel width (see 27.16.1 (Basic HE BSS functionality)) when the 20 MHz-only non-AP HE STA is operating in the 5 GHz band

— Clause 19 (High Throughput (HT) PHY specification) when the HE STA is operating in the 2.4 GHz band

The HE PHY with greater than or equal to 80 MHz capability is based on the VHT PHY defined in Clause 21 (Very High Throughput (VHT) PHY specification), which in turn is based on the HT PHY defined in Clause 19 (High Throughput (HT) PHY specification), which in turn is further based on the OFDM PHY defined in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification). The HE PHY with 20 MHz-only capability (see 28.3.9 (Mathematical description of signals)) is based on the HT PHY defined in Clause 19, which in turn is based on the OFDM PHY defined in Clause 17.

The HE PHY extends the maximum number of users supported for downlink multi-user MIMO (MU-MIMO) transmissions to eight and provides support for downlink and uplink orthogonal frequency division multiple access (OFDMA) as well as for uplink MU-MIMO. Both downlink and uplink MU-MIMO transmissions are supported on portions of the PPDU bandwidth (on resource units greater than or equal to 106 tones). In an MU-MIMO resource unit, there is support for up to eight users with up to four space-time streams per user with the total number of space-time streams not exceeding eight.

The HE PHY provides support for 20 MHz, 40 MHz, 80 MHz and 160 MHz contiguous channel widths and support for 80+80 MHz non-contiguous channel width, depending on the frequency band and capability. For channel widths greater than or equal to 80 MHz, the HE PHY supports preamble puncturing transmissions where one or more of the non-primary 20 MHz channels in an HE MU PPDU with more than one resource unit (RU) are zeroed out.

The HE PHY provides support for 0.8 μs, 1.6 μs and 3.2 μs guard interval durations.

The HE PHY provides support for 3.2 μs (1x), 6.4 μs (2x), and 12.8 μs (4x) HE-LTF durations. The HE PHY supports a DFT period of 3.2 μs and 12.8 μs for the pre-HE modulated fields and the HE modulated fields in an HE PPDU, respectively.The HE PHY data subcarrier frequency spacing is a quarter of VHT PHY and HT PHY subcarrier frequency spacing defined in Clause 21 (Very High Throughput (VHT) PHY specification) and Clause 19 (High Throughput (HT) PHY specification), respectively.

The HE PHY data subcarriers are modulated using binary phase shift keying (BPSK), BPSK dual-carrier modulation (DCM), quadrature phase shift keying (QPSK), QPSK DCM, 16-quadrature amplitude modulation (16-QAM), 16-QAM DCM, 64-QAM, 256-QAM and 1024-QAM. Forward error correction (FEC) coding (convolutional or LDPC coding) is used with coding rates of 1/2, 2/3, 3/4 and 5/6.

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The HE PHY supports the regulatory requirements in 21.3.13 (Regulatory requirements).

An HE STA shall support the following features:

— Transmission and reception of an HE SU PPDU that consists of a single RU spanning the entire PPDU bandwidth

— Transmission and reception of an HE ER SU PPDU that consists of a 242-tone RU spanning the entire primary 20 MHz PPDU bandwidth

— Binary convolutional coding (transmit and receive). Binary convolutional coding is not used for the following:

  • An HE SU PPDU with a bandwidth greater than 20 MHz
  • An RU of size greater than 242 subcarriers in an HE MU PPDU
  • An HE TB PPDU on an RU of size greater than 242 subcarriers
  • An HE SU PPDU with number of spatial streams greater than 4
  • An RU allocated to a single user in an HE MU PPDU with number of spatial streams greater than 4
  • An HE TB PPDU on an RU allocated to a single user with number of spatial streams greater than 4
  • An HE PPDU using HE-MCSs 10 or 11

— LDPC coding (transmit and receive) in all supported HE PPDU types, RU sizes, and number of spatial streams if the STA supports transmitting and receiving HE SU PPDUs of bandwidths greater than 20 MHz

— LDPC coding (transmit) in all supported HE PPDU types, RU sizes, and number of spatial streams if the STA declares support for transmitting more than 4 spatial streams

— LDPC coding (receive) in all supported HE PPDU types, RU sizes, and number of spatial streams if the STA declares support for receiving more than 4 spatial streams

— LDPC (transmit and receive) in all supported HE PPDU types, RU sizes, and number of spatial streams if the STA declares support for HE-MCSs 10 and 11 (transmit and receive)

— Transmit and receive of HE-SIG-B field in HE MU PPDUs at HE-MCSs 0 to 5

— Single spatial stream HE-MCSs 0 to 7 (transmit and receive) in all supported channel widths and RU sizes for HE SU PPDUs, HE MU PPDUs, and HE TB PPDUs

— 0.8 μs and 1.6 μs GI duration on both HE-LTF and data symbols when the 2x HE-LTF is used (transmit and receive)

— 1.6 μs GI duration on both HE-LTF and data symbols when the 1x HE-LTF is used (transmit and receive) for full bandwidth UL MU-MIMO if the STA supports UL MU-MIMO

— 3.2 μs GI duration on both HE-LTF and data symbols when the 4x HE-LTF is used (transmit and receive)

— HE SU PPDUs and HE MU PPDUs with 0.8 μs GI duration on both the HE-LTF and Data field symbols when the HE-LTF is a 4x LTF if the STA supports HE ER SU PPDUs with 0.8 μs GI duration on both the HE-LTF and Data field symbols when the HE-LTF is a 4x LTF (transmit and receive)

— Single spatial stream HE-MCSs 0 to 2 in primary 20 MHz channel for HE ER SU PPDUs

— 20 MHz channel width and all RU sizes and locations applicable to the 20 MHz channel width in 2.4 GHz and 5 GHz bands (transmit and receive)

An HE STA may support the following features:

— HE-MCSs 8 to 11 (transmit and receive)

— Two or more spatial streams (transmit and receive)

— Dual carrier modulation (transmit and receive)

— HE SU PPDUs with 0.8 μs GI duration on both the HE-LTF and Data field symbols when the HE-LTF is a 1x LTF (transmit and receive)

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- HE SU PPDUs and HE MU PPDUs with 0.8 μs GI duration on both the HE-LTF and Data field symbols when the HE-LTF is a 4x LTF if the STA does not support HE ER SU PPDUs with 0.8 μs GI duration on both the HE-LTF and Data field symbols when the HE-LTF is a 4x LTF (transmit and receive)
- HE ER SU PPDUs with 0.8 μs GI duration on both the HE-LTF and Data field symbols when the HE-LTF is a 4x LTF (transmit and receive)
- LDPC coding (transmit) if the maximum number of spatial streams the STA is capable of transmitting in an HE SU PPDU is less than or equal to 4
- LDPC coding (receive) if the maximum number of spatial streams the STA is capable of receiving in an HE SU PPDU is less than or equal to 4
- Single spatial stream HE-MCS 0 in the higher frequency 106-tone RU of the primary 20 MHz channel for an HE ER SU PPDU
- STBC (transmit and receive)

An HE AP shall support the following features:

- Transmission of an HE MU PPDU where none of the RUs utilize MU-MIMO (DL OFDMA)
- Reception of an HE TB PPDU where none of the RUs utilize MU-MIMO (UL OFDMA)
- Transmission of an HE MU PPDU consisting of a single RU spanning the entire PPDU bandwidth and utilizing MU-MIMO (DL MU-MIMO), provided the AP is capable of transmitting 4 or more spatial streams
- 40 MHz and 80 MHz channel widths and all RU sizes and locations applicable to the 40 MHz and 80 MHz channel width in 5 GHz band (transmit and receive)

An HE AP may support the following features:

- MU-MIMO transmission on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth (downlink MU-MIMO with OFDMA)
- MU-MIMO reception on an RU in an HE TB PPDU where the RU spans the entire PPDU bandwidth (uplink MU-MIMO)
- MU-MIMO reception on an RU in an HE TB PPDU where the RU does not span the entire PPDU bandwidth (uplink MU-MIMO with OFDMA)
- Reception of the payload on an RU in an HE MU PPDU where RU spans the entire PPDU bandwidth or a 106-tone RU within 20 MHz PPDU bandwidth
- 40 MHz channel width in the 2.4 GHz band (transmit and receive). If it is supported then all RU sizes and locations applicable to 40 MHz channel width are supported in 2.4 GHz band (transmit and receive)
- 160 MHz and 80+80 MHz channel widths and 2×996-tone RU size applicable to the 160/80+80 MHz channel width in 5 GHz band (transmit and receive)
- Transmission of an HE MU PPDU with preamble puncturing

A non-AP HE STA shall support the following features:

- Reception of an HE MU PPDU where the RU allocated to the non-AP STA is not utilizing MU-MIMO (DL OFDMA)
- Transmission of an HE TB PPDU where the RU allocated to the non-AP STA is not utilizing MU-MIMO (UL OFDMA)
- Reception of an HE MU PPDU consisting of a single RU spanning the entire PPDU bandwidth and utilizing MU-MIMO (DL MU-MIMO). The maximum number of spatial streams per user the non-AP STA can receive in the DL MU-MIMO transmission shall be equal to the minimum of 4 and the maximum number of spatial streams supported for reception of HE SU PPDUs. The non-AP STA

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shall be able to receive its intended spatial streams in a DL MU-MIMO transmission with a total number of spatial streams of at least 4.

— Responding with the requested beamforming feedback in an HE sounding procedure with the maximum number of space-time streams in the HE NDP that the non-AP STA can respond to being at least 4

— 40 MHz and 80 MHz channel widths and all RU sizes and locations applicable to the 40 MHz and 80 MHz channel widths in the 5 GHz band (transmit and receive) except for a 20 MHz-only non-AP HE STA in which case the 40 MHz and 80 MHz channel widths, 996-tone RU, and 484-tone RU sizes in 5 GHz band are not applicable

— A 20 MHz-only non-AP HE STA shall support 26-, 52-, and 106-tone RU sizes and locations in 40 MHz channel width in the 2.4 GHz band and 40 MHz and 80 MHz channel width in 5 GHz band (transmit and receive)

A non-AP HE STA may support the following:

— Transmission of an HE MU PPDU

— 40 MHz channel width in the 2.4 GHz band (transmit and receive). If 40 MHz channel width in the 2.4 GHz band is supported then all RU sizes and locations applicable to 40 MHz channel width are supported. Not applicable to a 20 MHz-only non-AP HE STA.

— For a 20 MHz-only non-AP HE STA, 26-, 52-, 106-, and 242-tone RU sizes and locations in 40 MHz channel width in the 2.4 GHz band

— For a 20 MHz operating non-AP HE STA, 26-, 52-, 106-, and 242-tone RU sizes and locations in 160 MHz and 80+80 MHz channel widths in the 5 GHz band

— 160 MHz and 80+80 MHz channel width and 2×996-tone RU size applicable to the 160 MHz and 80+80 MHz channel width in the 5 GHz band (transmit and receive). Not applicable to a 20 MHz-only non-AP HE STA.

— MU-MIMO reception on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth (DL MU-MIMO with OFDMA). The maximum number of spatial streams per user in the DL MU-MIMO with OFDMA transmission that the non-AP STA can receive shall be a minimum of 4 and the maximum number of spatial streams supported for reception of HE SU PPDUs. The total number of spatial streams in the DL MU-MIMO with OFDMA transmission that the non-AP STA can receive shall be at least 4

— MU-MIMO transmission on an RU in an HE TB PPDU where the RU spans the entire PPDU bandwidth (UL MU-MIMO). If it is supported then a total of up to 8 space-time streams are supported

— MU-MIMO transmission on an RU in an HE TB PPDU where the RU does not span the entire PPDU bandwidth (UL MU-MIMO with OFDMA). If it is supported then a total of up to 8 space-time streams are supported

— For a non-AP HE STA capable of up to 80 MHz channel width, when operating with 80 MHz channel width, the reception of 160 MHz or 80+80 MHz HE MU PPDU, or the transmission of 160 MHz or 80+80 MHz HE TB PPDU

28.1.2 Scope

The services provided to the MAC by the HE PHY consist of the following protocol functions:

a) A function that maps the PSDU received from the MAC into a PPDU for transmission to one or more receiving STAs.

b) A function that defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more STAs. Depending on the PPDU format, these STAs support a mixture of HE, Clause 21 (Very High Throughput (VHT) PHY specification), Clause 19 (High Throughput (HT) PHY specification) and Clause 17 (Orthogonal frequency division multiplexing

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(OFDM) PHY specification) PHYs. A non-AP STA with 20 MHz-only capability supports a mixture of HE, Clause 19 and Clause 17 PHYs.

28.1.3 HE PHY functions

28.1.3.1 General

The HE PHY contains two functional entities: the PHY function, and the physical layer management function (i.e., the PLME). Both of these functions are described in detail in 28.3 (HE PHY) and 28.4 (HE PLME). The HE PHY service is provided to the MAC through the PHY service primitives defined in Clause 8 (PHY service specification). The HE PHY service interface is described in 28.2 (HE PHY service interface).

28.1.3.2 PHY management entity (PLME)

The PLME performs management of the local PHY functions in conjunction with the MLME.

28.1.3.3 Service specification method

The models represented by figures and state diagrams are intended to be illustrations of the functions provided. It is important to distinguish between a model and a real implementation. The models are optimized for simplicity and clarity of presentation.

The service of a layer is the set of capabilities that it offers to a user in the next higher layer. Abstract services are specified here by describing the service primitives and parameters that characterize each service. This definition is independent of any particular implementation.

28.1.4 PPDU formats

The structure of the PPDU transmitted by an HE STA is determined by the TXVECTOR parameters as defined in Table 28-1 (TXVECTOR and RXVECTOR parameters).

The FORMAT parameter determines the overall structure of the PPDU and can take on one of the following values:

— Non-HT format (NON_HT), based on Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) and including non-HT duplicate format.

— HT-mixed format (HT_MF) as specified in Clause 19 (High Throughput (HT) PHY specification).

— HT-greenfield format (HT_GF) as specified in Clause 19 (High Throughput (HT) PHY specification).

— VHT format (VHT) as defined in Clause 21 (Very High Throughput (VHT) PHY specification).

— HE SU PPDU format (HE_SU) carries a single PSDU. With this format the HE-SIG-A field is not repeated. Support for the HE SU PPDU format is mandatory.

— HE ER SU PPDU format (HE_EXT_SU) carries a single PSDU. It is similar to the HE SU PPDU format, except that the HE-SIG-A field is repeated. Support for the HE ER SU PPDU format is mandatory.

— HE MU PPDU format (HE_MU) carries one or more PSDUs to one or more users. Support for the HE MU PPDU format is mandatory.

— HE TB PPDU format (HE_TRIG) carries a single PSDU and is sent in response to a PPDU that carries a Trigger frame or a frame that contains a UMRS Control field. The preamble format prior to the HE-STF field is identical to the HE SU PPDU. Support for the HE TB PPDU format is mandatory.

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28.2 HE PHY service interface

28.2.1 Introduction

The PHY provides an interface to the MAC through an extension of the generic PHY service interface defined in 8.3.4 (Basic service and options). The interface includes TXVECTOR, RXVECTOR, and PHY-CONFIG_VECTOR.

Using the TXVECTOR, the MAC supplies the PHY with per-PPDU transmit parameters. Using the RXVECTOR, the PHY informs the MAC of the received PPDU parameters. Using the PHYCONFIG_VECTOR, the MAC configures the PHY for operation, independent of frame transmission or reception.

28.2.2 TXVECTOR and RXVECTOR parameters

The parameters in Table 28-1 (TXVECTOR and RXVECTOR parameters) are defined as part of the TXVECTOR parameter list in the PHY-TXSTART.request primitive and/or as part of the RXVECTOR parameter list in the PHY-RXSTART.indication and PHY_RXEND.indication primitives.

Table 28-1—TXVECTOR and RXVECTOR parameters

Parameter	Condition	Value	TXVECTOR	RXVECTOR
FORMAT		Determines the format of the PPDU. Enumerated type: NON_HT indicates Clause 15, Clause 16, Clause 17, Clause 18 or non-HT duplicate PPDU format. In this case, the modulation is determined by the NON_HT_MODULATION parameter. HT_MF indicates HT-mixed format. HT_GF indicates HT-greenfield format. VHT indicates VHT format. HE_SU indicates HE SU PPDU format. HE_MU indicates HE MU PPDU format. HE_EXT_SU indicates HE ER SU PPDU format. HE_TRIG indicates HE TB PPDU format.	Y	Y
NON_HT_MODULATION	See corresponding entry in Table 19-1 (TXVECTOR and RXVECTOR parameters).			

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

L_LENGTH	FORMAT is HE_SU, HE_MU or HE_EXT_SU	Not present. NOTE—The Length field of the L-SIG for HE PPDU is defined in Equation (28-11) using the TXTIME value defined in 28.4.3 (TXTIME and PSDU_LENGTH calculation), which in turn depend on other parameters including the TXVECTOR parameter APEP_LENGTH.	N	N
	FORMAT is HE_TRIG	Indicates the value in the Length field of the L-SIG in the range of 1 to 4095. The value is obtained from the Trigger frame to which the HE TB PPDU is a response.	Y	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
L_DATARATE	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present NOTE—The RATE field in the L-SIG field in HE PPDU is set to the value representing 6 Mb/s in the 20 MHz channel spacing column of Table 17-6 (Contents of the SIGNAL field).	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
LSIGVALID	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
SERVICE	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
SMOOTHING	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
AGGREGATION	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
NUM_EXTEN_SS	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

ANTENNA_SET	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
N_TX	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Indicates the number of transmit chains.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
EXPANSION_MAT_TYPE	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Set to COMPRESSED_SV.	Y	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
EXPANSION_MAT	FORMAT is HE_SU, HE_EXT_SU or HE_TRIG	Contains a vector in the number of selected subcarriers containing feedback matrices as defined in 28.3.15.2 (Beamforming feedback matrix V) based on the channel measured during the training symbols of previous HE NDP PPDUs or VHT NDP PPDUs.	Y	N
	FORMAT is HE_MU	For each user, contains a vector in the number of all the subcarriers within the RU which is assigned to this user. The vector for each subcarrier contains feedback matrices as defined in in 28.3.15.2 (Beamforming feedback matrix V) based on the channel measured during the training symbols of previous HE NDP PPDUs or VHT NDP PPDUs.	M U	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
CHAN_MAT_TYPE	FORMAT is HE_SU and PSDU_LENGTH is 0	Set to COMPRESSED_SV.	N	Y
	FORMAT is HE_MU, HE_EXT_SU or HE_TRIG. FORMAT is HE_SU and PSDU_LENGTH is greater than 0.	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

CHAN_MAT	FORMAT is HE_SU and PSDU_LENGTH is 0	Contains a vector in the number of selected subcarriers containing feedback matrices as defined in 28.3.15.2 (Beamforming feedback matrix V) based on the channel measured during the training symbols of previous HE NDP PPDU.	N	Y
	FORMAT is HE_MU, HE_EXT_SU or HE_TRIG. FORMAT is HE_SU and PSDU_LENGTH is greater than 0.	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
DELTA_SNR	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Contains an array of delta SNR values as defined in 9.4.1.64 (HE MU Exclusive Beamforming Report field) based on the channel measured during the training symbols of the received HE NDP PPDU. NOTE—In the RXVECTOR this parameter is present only for HE NDP PPDUs for MU sounding.	M U	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
RCPI	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).			
SNR	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	For an HE SU PPDU and HE ER SU PPDU, contains an array of average values of received SNR measurements for each spatial stream. For an HE MU PPDU, contains an array of average values of received SNR measurements for each and every spatial stream on allocated RUs. For an HE TB PPDU, contains an array of average values of received SNR measurements for each and every spatial stream per user on allocated RUs. SNR indications of 8 bits are supported. Average value of SNR shall be the sum of the decibel values of SNR per tone divided by the number of tones represented in each stream as described in 9.4.1.63 (HE Compressed Beamforming Report field).	N	M U
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
CQI	FORMAT is HE_SU and PSDU_LENGTH is 0	Contains an array of received per-RU average SNRs for each space-time stream, where each per-RU average SNR is the arithmetic mean of the SNR in decibels over a 26-tone RU as described in 9.4.1.65 (HE CQI-only Report field).	N	Y
	Otherwise	Not present.	N	N

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

NO_SIG_EXTN	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Indicates whether signal extension needs to be applied at the end of transmission. Integer: 1 indicates that no signal extension is present. 0 indicates that a signal extension might be present depending on other TXVECTOR parameters.	Y	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
FEC_CODING	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Indicates which FEC encoding is used. Enumerated type: BCC_CODING indicates binary convolutional code. LDPC_CODING indicates low-density parity check code.	M U	M U
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
LDPC_EXTRA_SYMBOL	FORMAT is HE_TRIG and FEC_CODING is LDPC_CODING	Indicates the presence of the extra OFDM symbol segment for LDPC in an HE TB PPDU. Integer: 1 indicates that an extra OFDM symbol for LDPC is present. 0 indicates that an extra OFDM symbol for LDPC is not present.	Y	N
	Otherwise	Not present.	N	N
STBC	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Indicates if STBC is used. In an HE MU PPDU where each RU includes no more than 1 user: Set to 1 to indicate that all RUs are STBC encoded in the Data field Set to 0 to indicate that no RU is STBC encoded in the Data field In an HE SU PPDU, HE ER SU PPDU or HE TB PPDU: Set to 1 to indicate that STBC is used in the Data field Set to 0 to indicate that STBC is not used in the Data field STBC is not applied in MU-MIMO RUs; in an HE MU PPDU if any RU is assigned to more than 1 user then STBC is 0 to indicate that no RU is STBC encoded in the Data field. STBC is applied only for a single spatial stream ($N_{SS} = 1$). DCM is not used in conjunction with STBC.	Y	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
GI_TYPE	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Indicates the length of the GI for the HE-LTF and HE-Data fields. Enumerated type: 0.8 μs 1.6 μs 3.2 μs NOTE—the length of GI for pre-HE modulated fields is 0.8 μs.	Y	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

TXPWR_LEVEL_INDEX	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	The allowed values for the TXPWR_LEVEL_INDEX parameter are in the range from 1 to numberOfOctets (dot11TxPowerLevelExtended)/2. This parameter is used to indicate which of the available transmit output power levels defined in dot11TxPowerLevelExtended shall be used for the current transmission.	Y	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
RSSI	FORMAT is HE_SU, HE_EXT_SU, HE_MU or HE_TRIG	The allowed values for the RSSI parameter are in the range 0 to 255 inclusive. This parameter is a measure by the PHY of the power observed at the antennas used to receive the current PPDU measured during the reception of the HE-LTF field. RSSI is intended to be used in a relative manner, and it is a monotonically increasing function of the received power.	N	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
RSSI_LEGACY	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	The allowed values for the RSSI_LEGACY parameter are in the range 0 to 255 inclusive. This parameter is a measure by the PHY of the power observed at the antennas used to receive the current PPDU measured during the reception of non-HE portion of the HE PPDU preamble. RSSI_LEGACY is intended to be used in a relative manner, and it is a monotonically increasing function of the received power.	N	Y
	Otherwise	Not present	N	N
MCS	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Indicates the modulation and coding schemes used in the transmission of the PPDU. Integer: range 0 to 11	M U	M U
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
DCM	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Set to 1 to indicate that dual carrier modulation is used for the HE-Data field. Set to 0 to indicate that dual carrier modulation is not used for the HE-Data field. NOTE—DCM is only applied to MCS0, MCS1, MCS3 and MCS4. DCM is only applied to 1 and 2 spatial streams. DCM is not applied to MU-MIMO. DCM is not applied in combination with STBC.	M U	M U
	Otherwise	Not present.		

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

MCS_SIG_B	FORMAT is HE_MU	Indicates the modulation and coding scheme used for HE-SIG-B field. Integer: 0 indicates MCS0 1 indicates MCS1 2 indicates MCS2 3 indicates MCS3 4 indicates MCS4 5 indicates MCS5	Y	Y
	Otherwise	Not present.	N	N
DCM_SIG_B	FORMAT is HE_ MU	Set to 1 to indicate that dual carrier modulation is used for the HE-SIG-B field. Set to 0 to indicate that dual carrier modulation is not used for the HE-SIG-B field.	Y	Y
	Otherwise	Not present.	N	N
SIG_B_COMPRESSION_MODE	FORMAT is HE_MU	Used to differentiate an HE MU PPDU using full bandwidth MU-MIMO transmission from an HE MU PPDU using OFDMA transmission. Integer: 1 indicates an HE MU PPDU using full bandwidth MU-MIMO transmission 0 indicates HE MU PPDU using OFDMA transmission	Y	N
	Otherwise	Not present.	N	N
REC_MCS	FORMAT is HE_SU, HE_MU or HE_EXT_SU	Indicates the MCS that the receiver recommends	N	O
	FORMAT is HE_TRIG	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

CH_BANDWIDTH	FORMAT is HE_SU	Indicates the channel width of the transmitted PPDU. Enumerated type: CBW20 for 20 MHz CBW40 for 40 MHz CBW80 for 80 MHz CBW160 for 160 MHz CBW80+80 for 80+80 MHz	Y	Y
	FORMAT is HE_EXT_SU	Indicates the channel width of the transmitted PPDU. Enumerated type: 242-tone RU Higher frequency 106-tone RU within the primary 20 MHz	Y	Y
	FORMAT is HE_MU	Indicates the channel width occupied by the preamble supporting preamble puncturing. See the Bandwidth field in Table 28-19 (HE-SIG-A field of an HE MU PPDU). Enumerated type: CBW20 for full 20 MHz CBW40 for full 40 MHz CBW80 for full 80 MHz CBW160 for full 160 MHz and 80+80 MHz HE-CBW-PUNC80-PRI for preamble puncturing in 80 MHz, where in the preamble only the secondary 20 MHz is punctured HE-CBW-PUNC80-SEC for preamble puncturing in 80 MHz, where in the preamble only one of the two 20 MHz sub-channels in secondary 40 MHz is punctured HE-CBW-PUNC160-PRI20 for preamble puncturing in 160 MHz or 80+80 MHz, where in the primary 80 MHz of the preamble only the secondary 20 MHz is punctured HE-CBW-PUNC160-SEC40 for preamble puncturing in 160 MHz or 80+80 MHz, where in the primary 80 MHz of the preamble the primary 40 MHz is present.	Y	Y
	FORMAT is HE_TRIG	Indicates the Bandwidth field of the HE-SIG-A in the transmitted or received PPDU. Enumerated type: CBW20 for 20 MHz CBW40 for 40 MHz CBW80 for 80 MHz CBW160 for 160 MHz CBW80+80 for 80+80 MHz NOTE—The TXVECTOR parameter CH_BANDWIDTH does not represent the channel width of the transmitted PPDU.	Y	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
DYN_BANDWIDTH_IN_NON_HT	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

CH_BAND-WIDTH_IN_NON_HT	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
LENGTH	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
APEP_LENGTH	FORMAT is HE_SU	If equal to 0, indicates an HE NDP PPDU. If greater than 0, indicates the number of octets in the range 1 to 6 500 531 in the A-MPDU pre-EOF padding (see 10.13.2) carried in the PSDU.	Y	O
	FORMAT is HE_MU, HE_EXT_SU or HE_TRIG	Set to a value greater than 0, indicating the number of octets in the range 1 to 6 500 531 in the A-MPDU pre-EOF padding (see 10.13.2 (A-MPDU length limit rules)) carried in the PSDU.	M U	O
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
PSDU_LENGTH	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Indicates the number of octets in the HE PSDU in the range of 0 to aPSDUMaxLength octets (see Table 28-50 (HE PHY characteristics)). A value of 0 indicates an HE NDP PPDU.	N	Y
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
USER_POSITION	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

NUM_STS	FORMAT is HE_SU	Indicates the number of space-time streams. Integer in the range 1-8.	Y	Y
	FORMAT is HE_EXT_SU	Indicates the number of space-time streams. Integer in the range 1-2.	Y	Y
	FORMAT is HE_MU	Indicates the number of space-time streams. Integer in the range: 1-4 per user per MU-MIMO RU in the TXVECTOR 1-4 per MU-MIMO RU in the RXVECTOR 1-8 per RU assigned to no more than 1 user in the TXVECTOR and RXVECTOR NUM_STS summed over all users per RU is not greater than 8.	M U	Y
	FORMAT is HE_TRIG	Indicates the number of space-time streams. Integer in the range: 1-4 for a MU-MIMO RU in the TXVECTOR 1-4 per user per MU-MIMO RU in the RXVECTOR 1-8 for an RU assigned to no more than 1 user in the TXVECTOR and RXVECTOR NUM_STS summed over all users per RU is not greater than 8.	M U	M U
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
GROUP_ID	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
PARTIAL_AID	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

TXOP_DURATION	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Provide the duration of TXOP. Enumerated type or integer: UNSPECIFIED indicates no NAV duration information (see 27.11.5 (TXOP_DURATION)). 0 – 8448 indicates a duration in units of 1 μs that is used to update the NAV for this TXOP (see 27.2.4 (Updating two NAVs)). When the value of the TXOP field in the HE-SIG-A of a received HE PPDU is less than 127, if B0 of the TXOP field is 0, the RXVECTOR parameter TXOP_DURATION is set to (8 × value of (B1 – B6) of the TXOP field). Otherwise, the RXVECTOR parameter TXOP_DURATION is set to (512 + 128 × value of (B1 – B6) of the TXOP field). See 27.11.5 (TXOP_DURATION) for more details.	Y	Y
	Otherwise	Not present.	N	N
SPATIAL_REUSE	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Indicates the spatial reuse parameter value. There is one value of the parameter for each of an HE SU PPDU, HE ER SU PPDU and HE MU PPDU. There are one to four values of the parameter present for an HE TB PPDU, with the number of values present dependent on the bandwidth of the PPDU. See the Spatial Reuse field definition in 28.3.10.7.2 (Content). See 27.5.3.3 (STA behavior for UL MU operation) and 27.11.6 (SPATIAL_REUSE).	Y	Y
	Otherwise	Not present	N	N
DOPPLER	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Set to 1 to indicate that either the midamble is present for the PPDU or that the channel is with high Doppler. Set to 0 otherwise.	Y	Y
	Otherwise	Not present	N	N
NUM_USERS	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present. NOTE—number of users for an HE SU PPDU, HE ER SU PPDU or HE TB PPDU is always 1. The number of users for an HE MU PPDU is determined by RU_ALLOCATION.	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

RU_ALLOCATION	FORMAT is HE_MU and SIG_B_COMPRESSION_-MODE is 0	For the TXVECTOR, indicates the RU Allocation subfield of Common field in the HE-SIG-B of the transmitted PPDU. 8 bits for 20 MHz and 40 MHz PPDU; 16 bits for 80 MHz PPDU; 32 bits for 160 MHz and 80+80 MHz PPDU. See 28.3.10.8.5 (HE-SIG-B common content) for details. For the RXVECTOR, 8 bits are used to indicate the RU allocated in the whole bandwidth with the same encoding scheme as in Table 9-25h (The encoding of B19–B13 of the RU Allocation subfield). See 9.3.1.23 (Trigger frame format) for details.	Y	Y
	FORMAT is HE_TRIG	8 bits are used to indicate the RU allocated in the whole bandwidth per user with the same encoding scheme as in Table 9-25h (The encoding of B19–B13 of the RU Allocation subfield). See 9.3.1.23 (Trigger frame format) for details.	Y	M U
	Otherwise	Not present	N	N
BEAMFORMED	FORMAT is HE_SU or HE_EXT_SU	Set to 1 if a beamforming steering matrix is applied to the waveform in an SU transmission. Set to 0 otherwise.	Y	Y
	FORMAT is HE_MU or HE_TRIG	For an RU assigned to no more than 1 user, set to 1 if a beamforming steering matrix is applied and set to 0 otherwise. For each user in an RU assigned to more than 1 user, always set to 0.	M U	O
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

CENTER_26_TONE_RU	FORMAT is HE_MU and CH_BANDWIDTH is CBW80, CBW160, HE-CBW-PUNC80-PRI, HE-CBW-PUNC80-SEC, HE-CBW-PUNC160-PRI20 or HE-CBW-PUNC160-SEC40.	Indicate the presence of the center 26-tone RU with regard to bandwidth. When the CH_BANDWIDTH parameter is set to CBW80, HE-CBW-PUNC80-PRI or HE-CBW-PUNC80-SEC: Set to 1 to indicate that a user is allocated to the center 26-tone RU (see Figure 28-7 (RU locations in an 80 MHz HE PPDU)); Set to 0 to indicate that no user is allocated to the center 26-tone RU. When the CH_BANDWIDTH parameter is set to CBW160, HE-CBW-PUNC160-PRI20 or HE-CBW-PUNC160-SEC40: Set to 0 to indicate that no user is allocated to either the center 26-tone RU of the lower frequency 80 MHz or that of the higher frequency 80 MHz; Set to 1 to indicate that a user is allocated to the center 26-tone RU of the lower frequency 80 MHz; Set to 2 to indicate that a user is allocated to the center 26-tone RU of the higher frequency 80 MHz; Set to 3 to indicate that a user is allocated to each of the center 26-tone RU of the lower frequency 80 MHz and that of the higher frequency 80 MHz individually; See 28.3.10.8.5 (HE-SIG-B common content) for details.	Y	N
	Otherwise	Not present	N	N
HE_LTF_TYPE	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Indicates the type of HE-LTF. Enumerated type: 1x HE-LTF for 3.2 μs with 0.8 μs or 1.6 μs GI 2x HE-LTF for 6.4 μs with 0.8 μs or 1.6 μs GI 4x HE-LTF for 12.8 μs with 0.8 μs or 3.2 μs GI See 28.3.10.10 (HE-LTF) for details.	Y	Y
	Otherwise	Not present.	N	N
HE_LTF_MODE	FORMAT is HE_TRIG	Integer: 0 indicates that the transmitted PPDU uses HE single stream pilot HE-LTF mode. 1 indicates the transmitted PPDU uses HE masked HE LTF sequence mode. It is only present for full bandwidth MU-MIMO not using 1x HE-LTF. See 28.3.10.10 (HE-LTF) for details.	Y	N
	Otherwise	Not present.	N	N
NUM_HE_LTF	FORMAT is HE_TRIG	Indicates the number of OFDM symbols in the HE-LTF field. See 27.5.3.3 (STA behavior for UL MU operation) for details.	Y	N
	Otherwise	Not present.	N	N

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

HE_SIGA_RESERVED	FORMAT is HE_TRIG	Indicates the Reserved field setting for HE-SIG-A2 of HE TB PPDU. See 27.5.3.3 (STA behavior for UL MU operation) and Table 28-20 (HE-SIG-A field of an HE TB PPDU) for details.	Y	N
	Otherwise	Not present.	N	N
STARTING_STS_NUM	FORMAT is HE_TRIG	Indicates the starting STS number in the global space-time streams for the UL MU MIMO.	Y	N
	Otherwise	Not present.	N	N
TXOP_PS_NOT_ALLOWED	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Not present	N	N
	Otherwise	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).		
TIME_OF_DE-PARTURE_RE-	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).			
RX_START_OF_ FRAME_OFFSET	See corresponding entry in Table 21-1 (TXVECTOR and RXVECTOR parameters).			
PREAMBLE_TYPE	FORMAT is NON_HT and NON_HT_MODULATION is one of ERP-DSSS ERP-CCK	Enumerated type: SHORTPREAMBLE LONGPREAMBLE	Y	Y
	Otherwise	Not present	N	N

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

NOMINAL_PACKET_PADDING	FORMAT is HE_SU, HE_MU or HE_EXT_SU	The Nominal Packet Padding value as defined in 9.4.2.237.5 (PPE Thresholds field). Possible values are 0 µs, 8 µs and 16 µs. If the PPDU contains at least one MPDU whose RA field is broadcast group address, then the value of NOMINAL_PACKET_PADDING is 16 µs.	M U	N
	Otherwise	Not present	N	N
TRIGGER_METHOD	FORMAT is HE_TRIG	Indicates the method used to trigger this HE TB PPDU transmission. Enumerated type: TRIGGER_FRAME for Trigger Frame UMRS for UMRS Control field	Y	N
	Otherwise	Not present	N	N
DEFAULT_PE_DURATION	FORMAT is HE_TRIG and TRIGGER_METHOD is UMRS	Duration of the PE field to be transmitted (see 27.5.3.3 (STA behavior for UL MU operation)).	Y	N
	Otherwise	Not present	N	N
PE_DURATION	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG.	The duration of the PE field in the received HE PPDU. Possible values are 0 µs, 4 µs, 8 µs, 12 µs and 16 µs. Enumerated type: PE0 for 0 µs PE1 for 4 µs PE2 for 8 µs PE3 for 12 µs PE4 for 16 µs	N	O
BEAM_CHANGE	FORMAT is HE_SU or HE_EXT_SU	Integer: 0 indicates that the pre-HE-STF portion of the PPDU is spatially mapped the same way as the first symbol of HE-LTF on each tone. 1 indicates that the pre-HE-STF portion of the PPDU is spatially mapped not the same way as the first symbol of HE-LTF.	Y	Y
	Otherwise	Not present	N	N
BSS_COLOR	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG	Set to a value in the range 0 to 63 (see 27.11 (Setting TXVECTOR parameters for an HE PPDU)).	Y	Y
	Otherwise	Not present	N	N

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

UPLINK_FLAG	FORMAT is HE_SU or HE_MU or HE_EXT_SU	Set to 1 if the HE PPDU is addressed to an AP. Set to 0 otherwise (see 27.11 (Setting TXVECTOR parameters for an HE PPDU)).	Y	Y
	Otherwise	Not present	N	N
STA_ID_LIST	FORMAT is HE_MU	Indicates the list of STA IDs for an HE MU PPDU (see 27.11 (Setting TXVECTOR parameters for an HE PPDU)).	Y	Y
	Otherwise	Not present	N	N
SCRAMBLER_INTIAL_STATE	FORMAT is NON_HT	In TXVECTOR, if present, indicates the initial state of the scrambler of the transmitted PPDU. In RXVECTOR, indicates the Scrambler Initialization value in the Service field, prior to descrambling.	O	Y
	FORMAT is HE_MU or HE_TRIG	Not present.	N	N
	Otherwise	Indicates the Scrambler Initialization value in the Service field, prior to descrambling.	N	Y
TRIGGER_RESPONDING	FORMAT is NON_HT	Boolean value: True indicates that the MAC entity requests that the PHY entity do synchronization as defined in 17.3.9.10 (Pre-correction accuracy requirements). False indicates that the MAC entity does not request that the PHY entity do synchronization as defined in 17.3.9.10 (Pre-correction accuracy requirements). Set to true if the non-HT or non-HT duplicate PPDU is sent in response to an MU-RTS Trigger frame. Set to false otherwise.	Y	N
	Otherwise	Not present	N	N
NDP_REPORT	FORMAT is HE_TRIG and PSDU_LENGTH = 0	Provides the detected status array on the resources assigned by the Trigger frame. The array has N_{STA} entries (N_{STA} is defined in 27.5.6.2 (STA behavior)) where each entry takes on the value: 1 if transmission is detected on the first group of the tone set 0 if transmission is detected on the second group of the tone set NONE if transmission is not detected on either group of the tone set.	N	Y
	Otherwise	Not present	N	N

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Table 28-1—TXVECTOR and RXVECTOR parameters *(continued)*

FEEDBACK_STATUS	FORMAT is HE_TRIG and APEP_LENGTH = 0	Indicates the value of the one bit used to modulate the tones in each tone set. See 28.3.17 (HE TB NDP feedback PPDU) and 27.5.6 (NDP feedback report procedure).	Y	N
	Otherwise	Not present	N	N
RU_TONE_SET_INDEX	FORMAT is HE_TRIG and APEP_LENGTH = 0	Indicates the RU tone set used for an HE TB NDP feedback report PPDU. See 28.3.17 (HE TB NDP feedback PPDU).	Y	N
	Otherwise	Not present	N	N
MIDAMBLE_PERIODICITY	FORMAT is HE_SU, HE_MU, HE_EXT_SU or HE_TRIG, and DOPPLER is 1	Indicates the midamble periodicity in number of OFDM symbols in the HE Data field. Integer value of 10 or 20.	Y	N
	Otherwise	Not present.	N	N

NOTE—In the "TXVECTOR" and "RXVECTOR" columns, the following apply:
Y = Present;
N = Not present;
O = Optional;
MU indicates that the parameter is present once for an HE SU PPDU and HE ER SU PPDU and present per user for an HE MU PPDU. For an HE TB PPDU, MU in the TXVECTOR column indicates that the parameter is present once and MU in the RXVECTOR column indicates the parameter is present per user. Parameters specified to be present per user are conceptually supplied as an array of values indexed by *u*, where *u* takes values 0 to NUM_USERS − 1.

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28.2.3 TRIGVECTOR parameters

The TRIGVECTOR carried in a PHY-TRIGGER.request primitive for PHY of AP to receive HE TB PPDU over each assigned RU. The parameters in Table 28-2 (TRIGVECTOR parameters) are defined as part of the TRIGVECTOR parameter list in the PHY-TRIGGER.request primitive.

Table 28-2—TRIGVECTOR parameters

Parameter	Value
CH_BANDWIDTH	Indicates the bandwidth in the HE-SIG-A of the HE TB PPDU. Enumerated type: CBW20 for 20 MHz CBW40 for 40 MHz CBW80 for 80 MHz CBW160 for 160 MHz CBW80+80 for 80+80 MHz
GI_HELTF TYPE	Indicates the GI and HE-LTF type of the coming HE TB PPDU. Enumerated type: 1x LTF + 1.6 us GI 2x LTF + 1.6 us GI 4x LTF + 3.2 us GI
MU-MIMO LTF MODE	Indicates the LTF mode of the UL MU-MIMO HE TB PPDU and not using 1x HE-LTF. Set to 0 to indicate that HE single stream pilot HE LTF mode is used. Set to 1 to indicate that HE masked HE LTF sequence mode is used.
NUMBER_OF_HELTF_SYMBOLS	Indicates the number of HE-LTF symbols present in the HE TB PPDU. Set to 0 for 1 HE-LTF symbol Set to 1 for 2 HE-LTF symbols Set to 2 for 4 HE-LTF symbols Set to 3 for 6 HE-LTF symbols Set to 4 for 8 HE-LTF symbols Other values are reserved.
STBC	Indicates the status of STBC encoding of the HE TB PPDU. Set to 1 if STBC encoding is used. Set to 0 otherwise.
LDPC_EXTRA_SYMBOL	Indicates the status of the LDPC extra symbol segment. Set to 1 if LDPC extra symbol segment is present Set to 0 otherwise.
PRE-FEC FACTOR	Indicates the pre-FEC padding factor. Set to 0 to indicate a pre-FEC padding factor of 4. Set to 1 to indicate a pre-FEC padding factor of 1. Set to 2 to indicate a pre-FEC padding factor of 2. Set to 3 to indicate a pre-FEC padding factor of 3.
PE DISAMBIGUITY	Indicates PE disambiguity. Set to 0 to indicate no PE disambiguity. Set to 1 to indicate PE disambiguity.
SPATIAL_REUSE	Indicates the value for the Spatial Reuse field in the HE-SIG-A field of the coming HE TB PPDU NOTE—For 20 MHz one SR field corresponding to entire 20 MHz (other 3 fields indicate identical values). For 40 MHz two SR fields for each 20 MHz (other 2 fields indicate identical values). For 80 MHz four SR fields for each 20 MHz. For 160 MHz four SR fields for each 40 MHz.

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Table 28-2—TRIGVECTOR parameters *(continued)*

Parameter	Value
DOPPLER	Indicates a high Doppler mode of transmission. Set to 0 to indicate a high Doppler mode of transmission. Set to 1 otherwise.
AID12 LIST	Carries the 12 LSBs of the AID of each triggered STA. NOTE—Each element of AIDLIST is (12-bit) AID of the corresponding HE TB PPDU. See the AID12 subfield in 9.3.1.23 (Trigger frame format) for more information of each element.
RU_ALLOCATION_LIST	8 bits are used per STA to indicate the RU allocated in the whole bandwidth with the same encoding scheme as in Table 9-25h (The encoding of B19–B13 of the RU Allocation subfield). See 9.3.1.23 (Trigger frame format).
CODINGTYPE_LIST	Carries the code type of each triggered STA in coming HE_TB PPDU. NOTE—Each element of CODINGTYPE_LIST indicates coding type of the corresponding HE TB PPDU. Please see Coding Type subfield in 9.3.1.23 (Trigger frame format) for more information of each element.
MCS_LIST	Carries the MCS of each triggered STA in coming HE_TB PPDU. NOTE—Each element of MCS_LIST indicates MCS of the corresponding HE TB PPDU. Please see Coding Type subfield in 9.3.1.23 (Trigger frame format) for more information of each element.
SS_ALLOCATION_LIST	Indicates spatial streams of each triggered STA in coming HE_TB PPDU. NOTE—Each element of SS_ALLOCATION_LIST indicates spatial streams of the corresponding HE TB PPDU.Please see SS Allocation subfield in 9.3.1.23 (Trigger frame format) for more information of each element.

28.2.4 PHYCONFIG_VECTOR parameters

The PHYCONFIG_VECTOR carried in a PHY-CONFIG.request primitive for a VHT PHY contains an OPERATING_CHANNEL parameter, which identifies the operating or primary channel. The PHY shall set dot11CurrentPrimaryChannel to the value of this parameter.

The PHYCONFIG_VECTOR carried in a PHY-CONFIG.request primitive for a VHT PHY contains a CHANNEL_WIDTH parameter, which identifies the operating channel width and takes one of the values 20 MHz, 40 MHz, 80 MHz, 160 MHz, and 80+80 MHz. The PHY shall set dot11CurrentChannelWidth to the value of this parameter.

The PHYCONFIG_VECTOR carried in a PHY-CONFIG.request primitive for a VHT PHY contains a CENTER_FREQUENCY_SEGMENT_0 parameter, which identifies the center frequency of the channel (or of segment 0 if the CHANNEL_WIDTH parameter indicates 80+80 MHz) and takes a value between 1 and 200. The PHY shall set dot11CurrentChannelCenterFrequencyIndex0 to the value of this parameter. The PHYCONFIG_VECTOR carried in a PHY-CONFIG.request primitive for a VHT PHY contains a CENTER_FREQUENCY_SEGMENT_1 parameter, which takes the value 0 if the CHANNEL_WIDTH parameter does not indicate 80+80 MHz, and otherwise identifies the center frequency of segment 1 and takes a value between 1 and 200. The PHY shall set dot11CurrentChannelCenterFrequencyIndex1 to the value of this parameter.

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28.2.5 Effects of CH_BANDWIDTH parameter on PPDU format

Table 28-2 (Interpretation of FORMAT, NON_HT Modulation and CH_BANDWIDTH parameters) shows the valid combinations of the FORMAT, NON_HT MODULATION and CH_BANDWIDTH parameters and the corresponding PPDU format and value of CH_OFFSET (if applicable). Other combinations are reserved.

Table 28-3— Interpretation of FORMAT, NON_HT Modulation and CH_BANDWIDTH parameters

FORMAT	NON_HT_ MODULATION	CH_BANDWIDTH	CH_OFFSET	PPDU format
HE	N/A	CBW20	N/A	The STA transmits an HE PPDU of 20 MHz bandwidth. If the BSS bandwidth is wider than 20 MHz, then the transmission shall use the primary 20 MHz channel.
HE	N/A	CBW40	N/A	The STA transmits an HE PPDU of 40 MHz bandwidth. If the BSS bandwidth is wider than 40 MHz, then the transmission shall use the primary 40 MHz channel.
HE	N/A	CBW80	N/A	The STA transmits an HE PPDU of 80 MHz bandwidth. If the BSS bandwidth is wider than 80 MHz, then the transmission shall use the primary 80 MHz channel.
HE	N/A	CBW160	N/A	The STA transmits an HE PPDU of 160 MHz bandwidth.
HE	N/A	CBW80+80	N/A	The STA transmits an HE PPDU of 80+80 MHz bandwidth.
HT_MF, HT_GF, VHT, NON-HT	See Table 21-2 (Interpretation of FORMAT, NON_HT_MODULATION, CH_BANDWIDTH, and CH_OFFSET parameters) and Table 19-2 (Interpretation of FORMAT, CH_BANDWIDTH and CH_OFFSET parameters)			

28.2.6 Support for NON-HT, HT and VHT formats

28.2.6.1 General

An HE STA logically contains Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 18 (Extended Rate PHY (ERP) specification), Clause 19 (High Throughput (HT) PHY specification), Clause 21 (Very High Throughput (VHT) PHY specification) and Clause 28 (High Efficiency (HE) PHY specification) PHYs. The MAC interacts with the PHYs via the Clause 28 (High Efficiency (HE) PHY specification) PHY service interface, which in turn interacts with the Clause 15 (DSSS PHY specification for the 2.4 GHz band

designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 18 (Extended Rate PHY (ERP) specification), Clause 19 (High Throughput (HT) PHY specification) PHY

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service interfaces and Clause 21 (Very High Throughput (VHT) PHY specification) as shown in Figure 28-1 (PHY interaction on transmit for various PPDU formats), Figure 28-2 (PHY interaction on receive for various PPDU formats), and Figure 28-3 (PHY-CONFIG and CCA interaction with various PPDU formats).

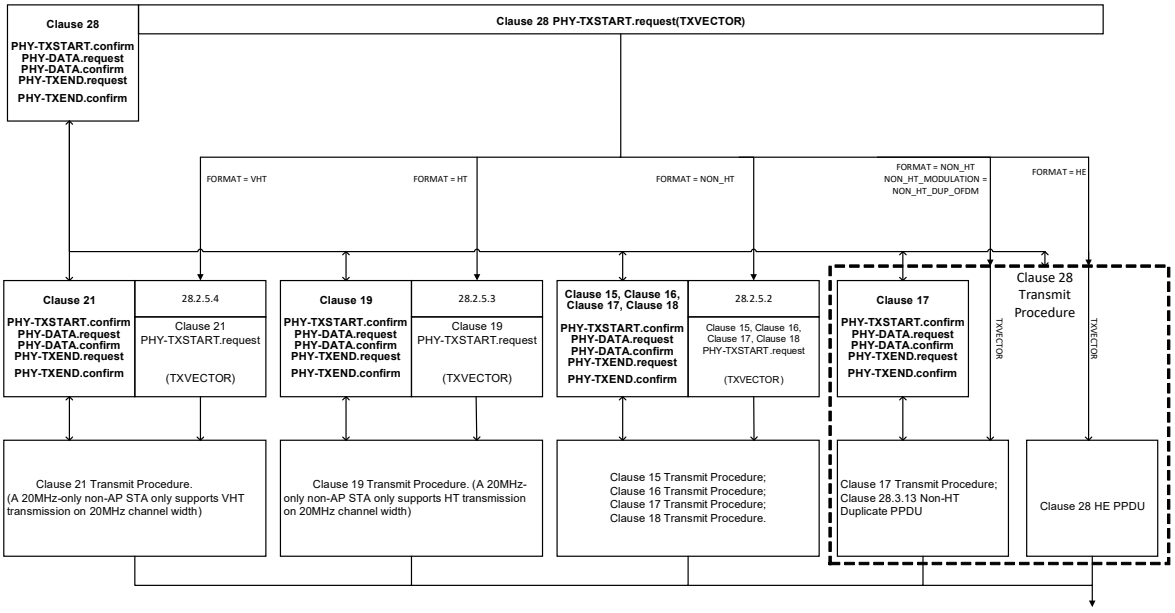


Figure 28-1—PHY interaction on transmit for various PPDU formats

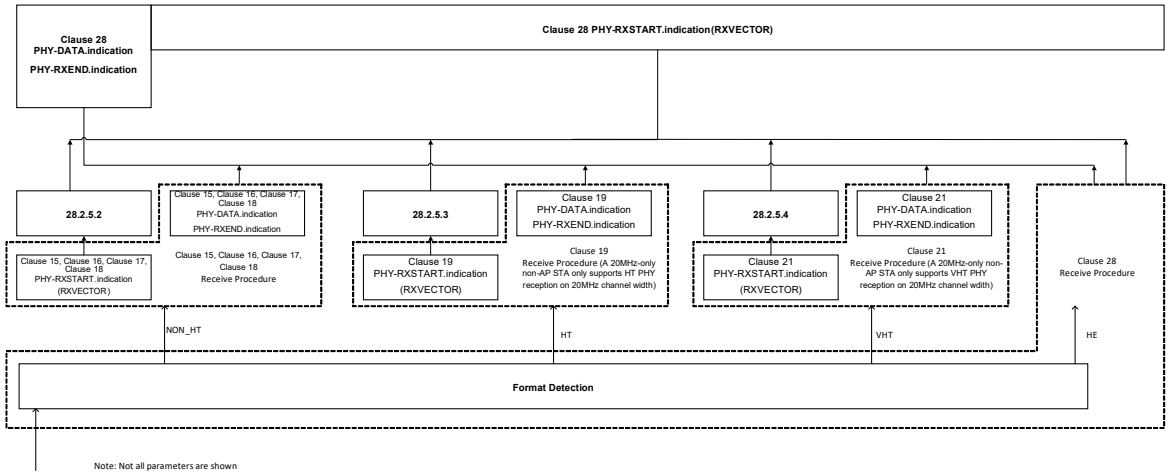


Figure 28-2—PHY interaction on receive for various PPDU formats

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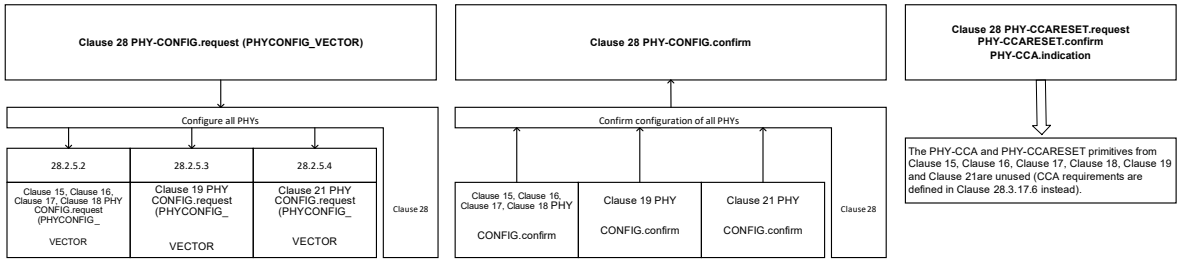


Figure 28-3—PHY-CONFIG and CCA interaction with various PPDU formats

28.2.6.2 Support for NON_HT format

When a PHY-TXSTART.request(TXVECTOR) primitive with the FORMAT parameter equal to NON_HT, the behavior of the HE PHY is defined in Clause 15 (DSSS PHY specification for the 2.4 GHz band

designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 18 (Extended Rate PHY (ERP) specification) PHYs respectively depends on the PPDU format. If the NON_HT_MODULATION is OFDM, there are additional requirements described in the following sub-clauses:

— 21.3.9.1 (Transmission of 20 MHz NON_HT PPDUs with more than one transmit chain)

— 21.3.17.1 (Transmit spectrum mask) instead of 17.3.9.3 (Transmit spectrum mask)

— 28.3.20.3 (Transmit center frequency leakage) instead of 17.3.9.7.2 (Transmitter center frequency leakage)

Where the Clause 28 (High Efficiency (HE) PHY specification) TXVECTOR parameters in Table 28-1 (TXVECTOR and RXVECTOR parameters) are mapped to Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 18 (Extended Rate PHY (ERP) specification) respectively according to Table 28-3 (Mapping of the HE PHY parameters for NON_HT operation). The HE PHY parameters not listed in the table are not present.

NOTE—When the FORMAT parameter is set to NON_HT and the NON_HT_MODULATION parameter is set to NON_HT_DUP_OFDM in a PHY-TXSTART.request(TXVECTOR) primitive, the behavior of the HE PHY is defined in Clause 28 (High Efficiency (HE) PHY specification).

When the HE PHY receives a Clause 28 (High Efficiency (HE) PHY specification) PHY-CONFIG.request(PHYCONFIG_VECTOR) primitive, the HE PHY shall behave as if it was a Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications) or Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification) or Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) or Clause 18 (Extended Rate PHY (ERP) specification) PHY that had received a PHYCONFIG.request(PHYCONFIG_VECTOR) primitive but with the CHANNEL_WIDTH, CENTER_FREQUENCY_SEGMENT_0, and CENTER_FREQUENCY_SEGMENT_1 parameters discarded from PHYCONFIG_VECTOR.

As defined in 28.3.21 (HE receive procedure), once a PPDU is received and detected as a NON_HT PPDU, the behavior of the HE PHY is defined in Clause 15 (DSSS PHY specification for the 2.4 GHz band

designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause

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18 (Extended Rate PHY (ERP) specification) PHYs respectively depends on the PPDU format. The RXVECTOR parameters from the Clause 15 (DSSS PHY specification for the 2.4 GHz band

designated for ISM applications), Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification), Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 18 (Extended Rate PHY (ERP) specification) are mapped to the Clause 28 (High Efficiency (HE) PHY specification) RXVECTOR parameters as defined in Table 28-4 (Mapping of the HE PHY parameters for NON_HT operation). The HE PHY parameters not listed in the table are not present.

Table 28-4—Mapping of the HE PHY parameters for NON_HT operation

HE PHY Parameter	2.4 GHz operation defined by Clause 15 (DSSS PHY specification for the 2.4 GHz band designated for ISM applications)	2.4 GHz operation defined by Clause 16 (High rate direct sequence spread spectrum (HR/DSSS) PHY specification)	2.4 GHz operation defined by Clause 18 (Extended Rate PHY (ERP) specification)	5 GHz operation defined by Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification)	Parameter List
L_LENGTH	LENGTH	LENGTH	LENGTH	LENGTH	TXVECTOR/ RXVECTOR
L_DATARATE	DATARATE	DATARATE	DATARATE	DATARATE	TXVECTOR/ RXVECTOR
TXPWR_LEVEL_INDEX	TXPWR_LEVEL_INDEX	TXPWR_LEVEL_INDEX	TXPWR_LEVEL_INDEX	TXPWR_LEVEL_INDEX	TXVECTOR
RSSI	RSSI	RSSI	RSSI	RSSI	RXVECTOR
SERVICE	SERVICE	SERVICE	SERVICE	SERVICE	TXVECTOR/ RXVECTOR
RCPI	RCPI	RCPI	RCPI	RCPI	RXVECTOR
CH_BANDWIDTH_IN_NON_HT	discarded	discarded	CH_BANDWIDTH_IN_NON_HT	CH_BANDWIDTH_IN_NON_HT	TXVECTOR/ RXVECTOR
DYN_BANDWIDTH_IN_NON_HT	discarded	discarded	DYN_BANDWIDTH_IN_NON_HT	DYN_BANDWIDTH_IN_NON_HT	TXVECTOR/ RXVECTOR
OPERATING_CHANNEL	discarded	discarded	discarded	OPERATING_CHANNEL	PHYCONFIG_VECTOR

28.2.6.3 Support for HT format

When a PHY-TXSTART.request(TXVECTOR) primitive is received with the TXVECTOR parameter FORMAT equal to HT_MF or HT_GF, the behavior of the PHY is defined by Clause 19 (High Throughput (HT) PHY specification) with additional requirements defined in the following subclauses:

— 21.3.9.2 (Transmission of HT PPDUs with more than four transmit chains)

— 21.3.17.1 (Transmit spectrum mask) instead of 19.3.18.1 (Transmit spectrum mask)

— 28.3.20.3 (Transmit center frequency leakage) instead of 19.3.18.4 (Transmit center frequency tolerance)

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Where the Clause 28 (High Efficiency (HE) PHY specification) TXVECTOR parameters in Table 28-1 (TXVECTOR and RXVECTOR parameters) are mapped directly to Clause 19 (High Throughput (HT) PHY specification) TXVECTOR parameters in Table 19-1 (TXVECTOR and RXVECTOR parameters) and the Clause 19 (High Throughput (HT) PHY specification) PHY-TXSTART.request (TXVECTOR) primitive is issued. The HE PHY parameters not listed in Table 19-1 are not present. The PHY shall use a value of CH_OFFSET in the Clause 19 (High Throughput (HT) PHY specification) TXVECTOR that is consistent with Table 28-3 (Interpretation of FORMAT, NON_HT Modulation and CH_BANDWIDTH parameters). The 20 MHz-only non-AP HE STA only supports HT transmission on 20 MHz channel width.

When the HE PHY receives a Clause 28 (High Efficiency (HE) PHY specification) PHY-CONFIG.request(PHYCONFIG_VECTOR) primitive, the HE PHY shall, for the purposes of HT PPDU transmission and reception, behave as if it were a Clause 19 (High Throughput (HT) PHY specification) PHY that had received PHY-CONFIG.request(PHYCONFIG_VECTOR) primitive but with the CHANNEL_WIDTH, CENTER_FREQUENCY_SEGMENT_0, and CENTER_FREQUENCY_SEGMENT_1 parameters discarded from the PHYCONFIG_VECTOR and the SECONDARY_CHANNEL_OFFSET parameter set to SECONDARY_CHANNEL_NONE if dot11CurrentChannelWidth indicates 20 MHz, to SECONDARY_CHANNEL_ABOVE if $f_{P20,idx} < f_{S20,idx}$, or to SECONDARY_CHANNEL_BELOW otherwise.

As defined in 28.3.22 (PHY receive procedure), once a PPDU is received and detected as an HT PPDU, the behavior of the HE PHY is defined in Clause 19 (High Throughput (HT) PHY specification). The RXVECTOR parameters in Table 19-1 (TXVECTOR and RXVECTOR parameters) from the Clause 19 (High Throughput (HT) PHY specification) PHY-RXSTART.indication primitive are mapped directly to the RXVECTOR parameters in Table 28-1 (TXVECTOR and RXVECTOR parameters) and a Clause 28 (High Efficiency (HE) PHY specification) PHY-RXSTART.indication primitive is issued. The HE PHY parameters not listed in Table 19-1 are not present. The 20 MHz-only non-AP HE STA only supports HT reception on 20 MHz channel width.

28.2.6.4 Support for VHT format

When a PHY-TXSTART.request(TXVECTOR) primitive is received with the TXVECTOR parameter FORMAT equal to VHT, the behavior of the PHY is defined by Clause 21 (Very High Throughput (VHT) PHY specification) with additional requirements defined in the following subclauses:

— 28.3.20.3 (Transmit center frequency leakage) instead of 21.3.17.4.2 (Transmit center frequency tolerance)

Where the Clause 28 (High Efficiency (HE) PHY specification) TXVECTOR parameters in Table 28-1 (TXVECTOR and RXVECTOR parameters) are mapped directly to Clause 21 (Very High Throughput (VHT) PHY specification) TXVECTOR parameters in Table 21-1 (TXVECTOR and RXVECTOR parameters) and the Clause 21 (Very High Throughput (VHT) PHY specification) PHY-TXSTART.request (TXVECTOR) primitive is issued. The HE PHY parameters not listed in Table 21-1 are not present. The 20 MHz-only non-AP HE STA only supports VHT transmission on 20 MHz channel width.

When the HE PHY receives a Clause 28 (High Efficiency (HE) PHY specification) PHY-CONFIG.request(PHYCONFIG_VECTOR) primitive, the HE PHY shall, for the purposes of VHT PPDU transmission and reception, behave as if it were a Clause 21 (Very High Throughput (VHT) PHY specification) PHY that had received PHY-CONFIG.request(PHYCONFIG_VECTOR) primitive .

As defined in 28.3.21 (HE receive procedure), once a PPDU is received and detected as an VHT PPDU, the behavior of the HE PHY is defined in Clause 21 (Very High Throughput (VHT) PHY specification). The RXVECTOR parameters in Table 21-1 (TXVECTOR and RXVECTOR parameters) from the Clause 21 (High Throughput (HT) PHY specification) PHY-RXSTART.indication primitive are mapped directly to the RXVECTOR parameters in Table 28-1 (TXVECTOR and RXVECTOR parameters) and a Clause 28 (High

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Efficiency (HE) PHY specification) PHY-RXSTART.indication primitive is issued. The HE PHY parameters not listed in Table 21-1 are not present. The 20 MHz-only non-AP HE STA only supports VHT reception on 20 MHz channel width.

28.3 HE PHY

28.3.1 Introduction

This subclause provides the procedure by which PSDUs are converted to and from transmissions on the wireless medium.

During transmission, a PSDU (in the SU case) or one or more PSDUs (in the MU case) are processed (i.e., scrambled and coded) and appended to the PHY preamble to create the PPDU. At the receiver, the PHY preamble is processed to aid in the detection, demodulation, and delivery of the PSDU.

28.3.2 MU transmission

28.3.2.1 Introduction

The MU transmissions include DL MU transmissions and UL MU transmissions.

DL MU transmission allows an AP to simultaneously transmit information to more than one non-AP STA. For a DL MU transmission, the AP uses the HE MU PPDU format and employs either DL OFDMA, DL MU-MIMO, or a mixture of both. UL MU transmission allows an AP to simultaneously receive information from more than one non-AP STA. The non-AP STAs transmit using the HE TB PPDU format and employ either UL OFDMA, UL MU-MIMO, or a mixture of both.

The HE PHY supports OFDMA transmissions, both in the DL and the UL where different users can occupy different RUs in a PPDU (see 28.3.9 (Mathematical description of signals)). The transmission within an RU in a PPDU may be single stream to one user, spatial multiplexed to one user (SU-MIMO), or spatial multiplexed to multiple users (MU-MIMO). Note that the VHT PHY supports only full bandwidth DL MU-MIMO as described in 21.3.11 (SU-MIMO and DL-MU-MIMO Beamforming). The HE PHY defines DL MU-MIMO and UL MU-MIMO, for both the full bandwidth case as well as for the partial bandwidth case where MU-MIMO is used only on certain RUs in the PPDU. The combination of SU transmissions and MU-MIMO transmissions on different RUs in one PPDU is also supported.

28.3.3 OFDMA and SU tone allocation

28.3.3.1 General

Orthogonal Frequency Division Multiple Access (OFDMA) is an OFDM-based multiple access scheme where different subsets of subcarriers are allocated to different users, allowing simultaneous data transmission to or from one or more users. In OFDMA, users are allocated different subsets of subcarriers which can change from one PPDU to the next. The difference between OFDM and OFDMA is illustrated in Figure 28-4 (Illustration of OFDM and OFDMA concepts). Similar to OFDM, OFDMA employs multiple subcarriers,

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but the subcarriers are divided into several groups of subcarriers where each group is denoted as a resource unit (RU). With OFDMA, different transmit powers may be applied to different RUs.

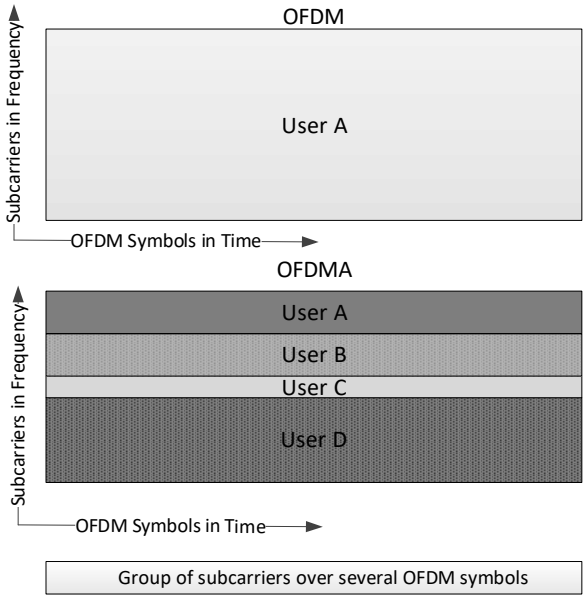


Figure 28-4—Illustration of OFDM and OFDMA concepts

In OFDMA, an OFDM symbol is constructed of subcarriers, the number of which is a function of the PPDU bandwidth. There are several subcarrier types:

1) Data subcarriers, which are used for data transmission (see 28.3.3.2 (Resource unit, guard and DC subcarriers))
2) Pilot subcarriers, which are used for phase information and parameter tracking (see 28.3.3.4 (Pilot subcarriers))
3) Unused subcarriers, which are not used for either data or pilot transmission. The unused subcarriers are the DC subcarrier (see 28.3.3.2 (Resource unit, guard and DC subcarriers)), the Guard band subcarriers at the band edges (see 28.3.3.2 (Resource unit, guard and DC subcarriers)), and the Null subcarriers (see 28.3.3.3 (Null subcarriers)).

28.3.3.2 Resource unit, guard and DC subcarriers

The resource units (RUs) defined for DL and UL transmission are as follows: 26-tone RU, 52-tone RU, 106-tone RU, 242-tone RU, 484-tone RU, 996-tone RU and 2×996-tone RU.

The 26-tone RU, 52-tone RU, 106-tone RU and 242-tone RU are used in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE MU PPDU format. The 52-tone RU, 106-tone RU and 242-tone RU are used in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE TB PPDU format. The 26-tone RU is used in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE TB PPDU format, except when a STA is operating in an operating class for which the behavior limits set listed in Annex E includes the DFS_50_100_Behavior (see 27.5.3.2.1 (General) and 27.5.3.3 (STA behavior for UL MU operation)). The 106-tone RU is used in the HE ER SU PPDU format.

The 484-tone RU is used in the 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE MU PPDU and HE TB PPDU formats. The 996-tone RU is used in the 80 MHz, 160 MHz and 80+80 MHz HE MU PPDU and HE

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TB PPDU formats. The 2×996-tone RU is used in the 160 MHz and 80+80 MHz HE MU PPDU format and 160 MHz and 80+80 MHz HE TB PPDU format.

The 242-tone and larger RUs are used in the HE SU PPDU format. The 242-tone RU is used in the 20 MHz HE SU PPDU and HE ER SU PPDU formats. The 484-tone RU is used in the 40 MHz HE SU PPDU format. The 996-tone RU is used in the 80 MHz HE SU PPDU format. The 2×996-tone RU is used in the 160 MHz and 80+80 MHz HE SU PPDU formats.

The maximum number of RUs in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz HE PPDU formats are defined in Table 28-5 (Maximum number of RUs for each channel width).

Table 28-5—Maximum number of RUs for each channel width

RU type	CBW20	CBW40	CBW80	CBW80+80 and CBW160
26-tone RU	9	18	37	74
52-tone RU	4	8	16	32
106-tone RU	2	4	8	16
242-tone RU	1	2	4	8
484-tone RU	N/A	1	2	4
996-tone RU	N/A	N/A	1	2
2×996 tone RU	N/A	N/A	N/A	1

An HE MU PPDU using OFDMA transmission can carry a mixture of 26-, 52-, 106-, 242-, 484-, and 996-tone RUs.

Table 28-6—Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU

RU type	RU index and subcarrier range				
26-tone RU	RU 1 [−121: −96]	RU 2 [−95: −70]	RU 3 [−68: −43]	RU 4 [−42: −17]	RU 5 [−16: −4, 4: 16]
	RU 6 [17: 42]	RU 7 [43: 68]	RU 8 [70: 95]	RU 9 [96: 121]	
52-tone RU	RU 1 [−121: −70]	RU 2 [−68: −17]	RU 3 [17: 68]	RU 4 [70: 121]	
106-tone RU	RU 1 [−122: −17]		RU 2 [17: 122]		
242-tone RU	RU 1 [−122: −2, 2:122]				
[x1: y1] means the frequency index of the RU from the lowest frequency index with x1 to the highest index of y1 by one increment. [x1: y1, x2: y2] means the frequency index of the RU from the lowest frequency index of x1 to y1 by one increment, and from the x2 to the highest frequency index of y2 by one increment.					

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Table 28-7—Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU

RU type	RU index and subcarrier range				
26-tone RU	RU 1 [−243: −218]	RU 2 [−217: −192]	RU 3 [−189: −164]	RU 4 [−163: −138]	RU 5 [−136: −111]
	RU 6 [−109: −84]	RU 7 [−83: −58]	RU 8 [−55: −30]	RU 9 [−29: −4]	
	RU 10 [4: 29]	RU 11 [30: 55]	RU 12 [58: 83]	RU 13 [84: 109]	RU 14 [111: 136]
	RU 15 [138: 163]	RU 16 [164: 189]	RU 17 [192: 217]	RU 18 [218: 243]	
52-tone RU	RU 1 [−243: −192]	RU 2 [−189: −138]	RU 3 [−109: −58]	RU 4 [−55: −4]	
	RU 5 [4: 55]	RU 6 [58: 109]	RU 7 [138: 189]	RU 8 [192: 243]	
106-tone RU	RU 1 [−243: −138]	RU 2 [−109: −4]	RU 3 [4: 109]	RU 4 [138: 243]	
242-tone RU	RU 1 [−244: −3]		RU 2 [3: 244]		
484-tone RU	RU 1 [−244: −3, 3: 244]				

[x1: y1] means the frequency index of the RU from the lowest frequency index with x1 to the highest index of y1 by one increment.
[x1: y1, x2: y2] means the frequency index of the RU from the lowest frequency index of x1 to y1 by one increment, and from the x2 to the highest frequency index of y2 by one increment.

Table 28-8—Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU

RU type	RU index and subcarrier range				
26-tone RU	RU 1 [−499: −474]	RU 2 [−473: −448]	RU 3 [−445: −420]	RU 4 [−419: −394]	RU 5 [−392: −367]
	RU 6 [−365: −340]	RU 7 [−339: −314]	RU 8 [−311: −286]	RU 9 [−285: −260]	
	RU 10 [−257: −232]	RU 11 [−231: −206]	RU 12 [−203: −178]	RU 13 [−177: −152]	RU 14 [−150: −125]
	RU 15 [−123: −98]	RU 16 [−97: −72]	RU 17 [−69: −44]	RU 18 [−43: −18]	RU 19 [−16: −4, 4: 16]
	RU 20 [18: 43]	RU 21 [44: 69]	RU 22 [72: 97]	RU 23 [98: 123]	RU 24 [125: 150]
	RU 25 [152: 177]	RU 26 [178: 203]	RU 27 [206: 231]	RU28 [232: 257]	
	RU 29 [260: 285]	RU 30 [286: 311]	RU 31 [314: 339]	RU 32 [340: 365]	RU 33 [367: 392]
	RU 34 [394: 419]	RU 35 [420: 445]	RU 36 [448: 473]	RU37 [474: 499]	

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Table 28-8—Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU

RU type	RU index and subcarrier range				
52-tone RU	RU 1 [−499: −448]	RU 2 [−445: −394]	RU 3 [−365: −314]	RU 4 [−311: −260]	
	RU 5 [−257: −206]	RU 6 [−203: −152]	RU 7 [−123: −72]	RU 8 [−69: −18]	
	RU 9 [18: 69]	RU 10 [72: 123]	RU 11 [152: 203]	RU 12 [206: 257]	
	RU 13 [260: 311]	RU 14 [314: 365]	RU 15 [394: 445]	RU 16 [448: 499]	
106-tone RU	RU 1 [−499: −394]	RU 2 [−365: −260]	RU 3 [−257: −152]	RU 4 [−123: −18]	
	RU 5 [18: 123]	RU 6 [152: 257]	RU 7 [260: 365]	RU 8 [394: 499]	
242-tone RU	RU 1 [−500: −259]	RU 2 [−258: −17]	RU 3 [17: 258]	RU 4 [259: 500]	
484-tone RU	RU 1 [−500: −17]		RU 2 [17: 500]		
996-tone RU	RU 1 [−500: −3, 3: 500]				

[x1: y1] means the frequency index of the RU from the lowest frequency index with x1 to the highest index of y1 by one increment.
[x1: y1, x2: y2] means the frequency index of the RU from the lowest frequency index of x1 to y1 by one increment, and from the x2 to the highest frequency index of y2 by one increment.

A 26-tone RU consists of 24 data subcarriers and 2 pilot subcarriers. The positions of the pilots for the 26-tone RU are defined in 28.3.3.4 (Pilot subcarriers). The location of the 26-tone RUs are fixed as defined in Table 28-6 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU), Table 28-7 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU) and shown in Figure 28-5 (RU locations in a 20 MHz HE PPDU), Figure 28-6 (RU locations in a 40 MHz HE PPDU) and Figure 28-7 (RU locations in an 80 MHz HE PPDU) for the 20 MHz, 40 MHz and 80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission, respectively. The same structure as used for the 80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz HE MU PPDU or HE TB PPDU formats using OFDMA transmission. The center 26-tone RU in the 20 MHz and 80 MHz HE MU PPDU or HE TB PPDU formats using OFDMA transmission (Figure 28-5 (RU loca-

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tions in a 20 MHz HE PPDU) and Figure 28-7 (RU locations in an 80 MHz HE PPDU)) is located on subcarriers [−16: −4, 4: 16].

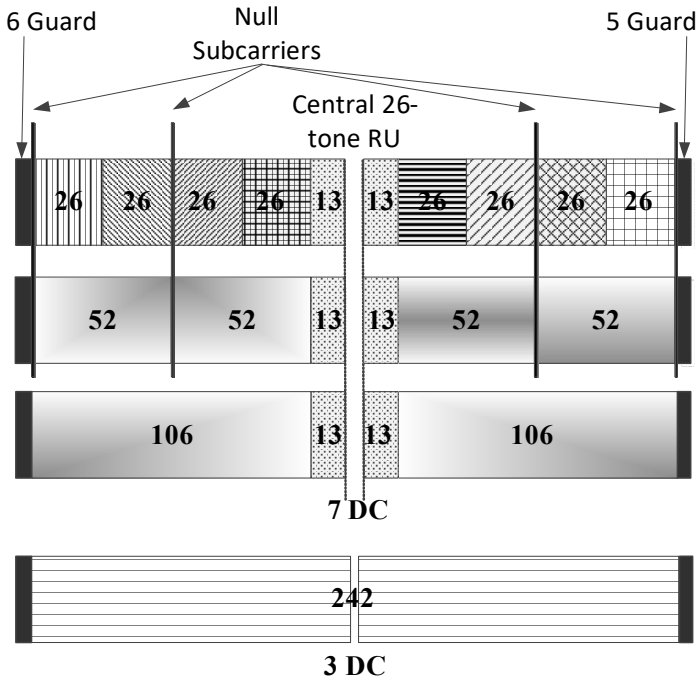


Figure 28-5—RU locations in a 20 MHz HE PPDU

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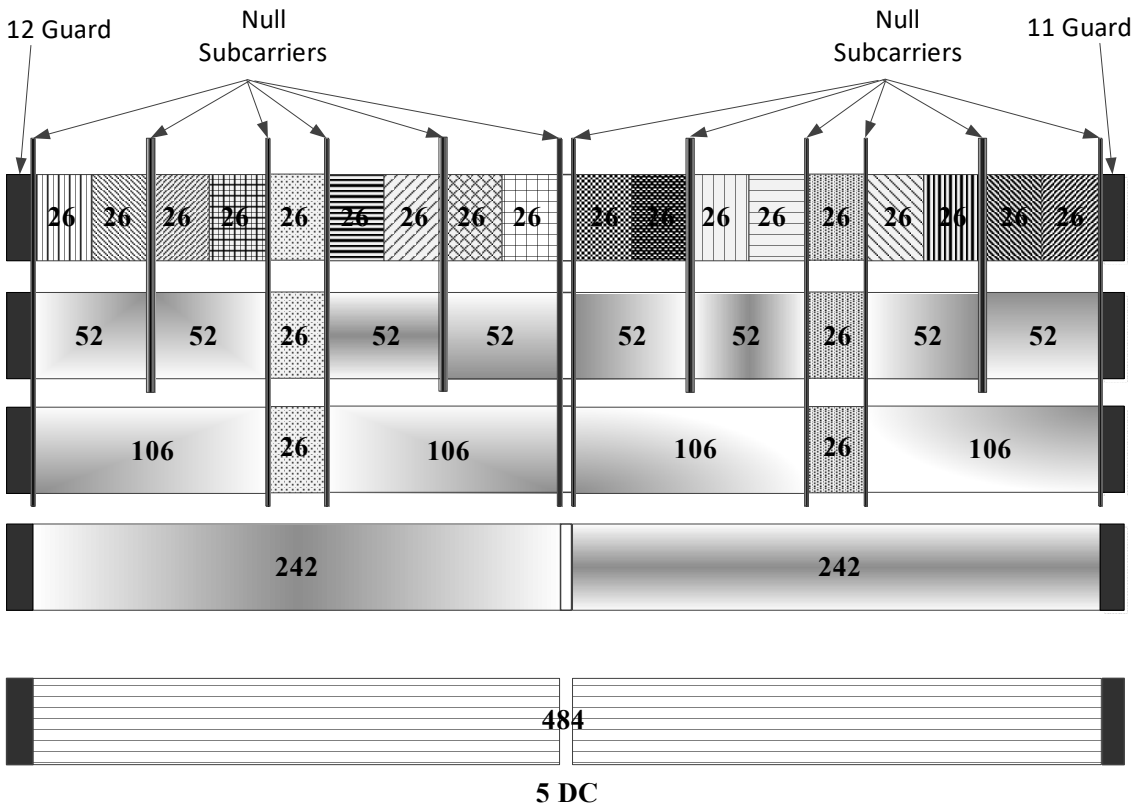


Figure 28-6—RU locations in a 40 MHz HE PPDU

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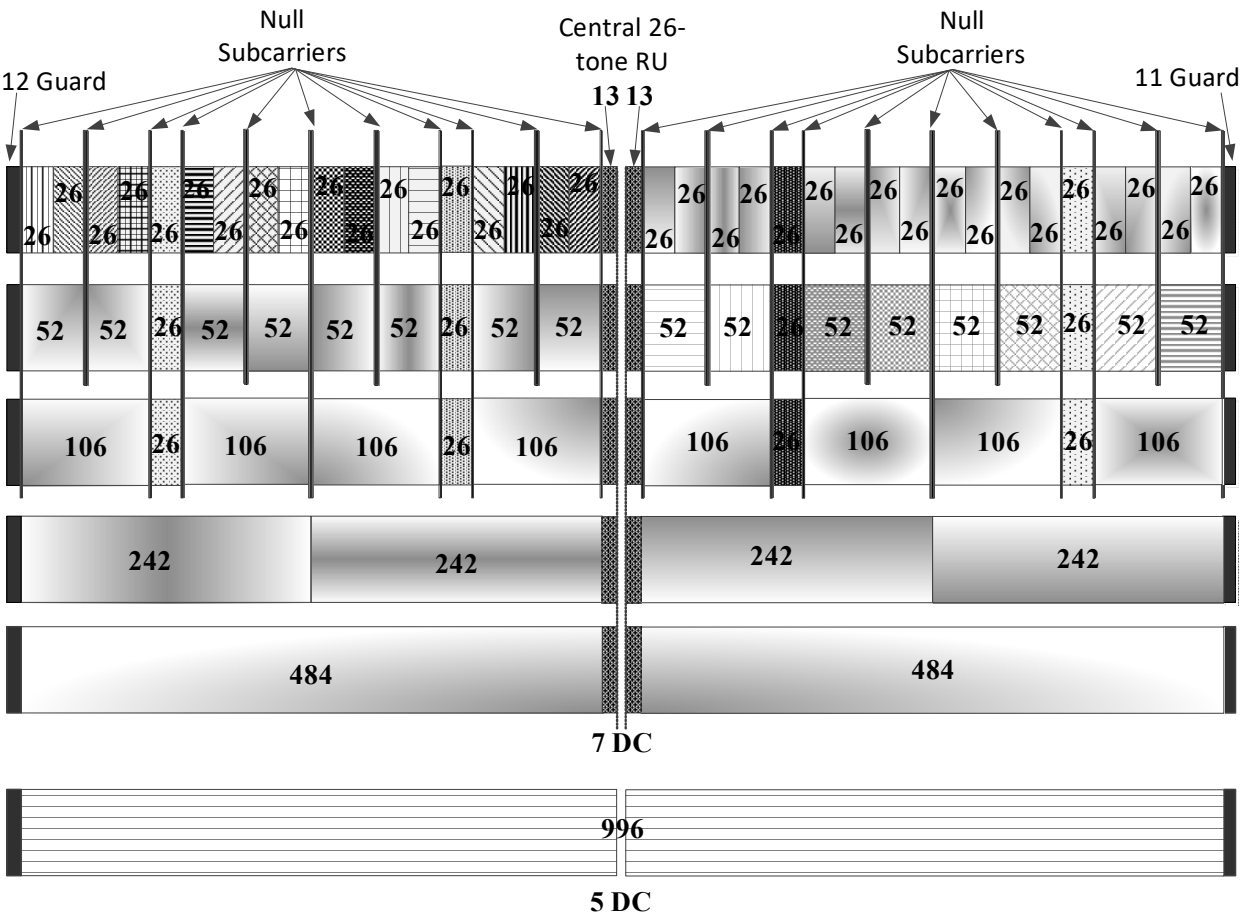


Figure 28-7—RU locations in an 80 MHz HE PPDU

A 52-tone RU consists of 48 data subcarriers and 4 pilot subcarriers. The positions of the pilots for the 52-tone RU are defined in 28.3.3.4 (Pilot subcarriers). The locations of the 52-tone RUs are fixed as defined in Table 28-6 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU), Table 28-7 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU) and illustrated in Figure 28-5 (RU locations in a 20 MHz HE PPDU), Figure 28-6 (RU locations in a 40 MHz HE PPDU) and Figure 28-7 (RU locations in an 80 MHz HE PPDU) for the 20 MHz, 40 MHz and 80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission, respectively. The same structure as used in the 80 MHz HE MU PPDU format or HE TB PPDU formats using OFDMA transmission is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission.

A 106-tone RU consists of 102 data subcarriers and 4 pilot subcarriers. The positions of the pilots for the 106-tone RU are defined in 28.3.3.4 (Pilot subcarriers). The locations of the 106-tone RUs are fixed as defined in Table 28-6 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU), Table 28-7 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU) and illustrated in Figure 28-5 (RU locations in a 20 MHz HE PPDU), Figure 28-6 (RU locations in a 40 MHz HE PPDU) and Figure 28-7 (RU locations in an 80 MHz HE PPDU) for the 20 MHz, 40 MHz and 80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission, respectively. The same structure as used in the 80 MHz HE MU PPDU formats or HE TB

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PPDU formats using OFDMA transmission is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz HE MU PPDU formats or HE TB PPDU formats using OFDMA transmission.

A 242-tone RU consists of 234 data subcarriers and 8 pilot subcarriers. The positions of pilots for the 242-tone RU are defined in 28.3.3.4 (Pilot subcarriers). The locations of the 242-tone RUs are fixed as defined in Table 28-6 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU), Table 28-7 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU) and illustrated in Figure 28-5 (RU locations in a 20 MHz HE PPDU), Figure 28-6 (RU locations in a 40 MHz HE PPDU) and Figure 28-7 (RU locations in an 80 MHz HE PPDU) for the 20 MHz, 40 MHz and 80 MHz HE PPDU formats, respectively. The same structure as used in the 80 MHz HE PPDU formats is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz HE PPDU formats.

A 484-tone RU consists of 468 data subcarriers and 16 pilot subcarriers. The position of the pilots for the 484-tone RU is defined in 28.3.3.4 (Pilot subcarriers). The locations of the 484-tone RUs are fixed as defined in Table 28-7 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU) and illustrated in Figure 28-6 (RU locations in a 40 MHz HE PPDU) and Figure 28-7 (RU locations in an 80 MHz HE PPDU) for the 40 MHz and 80 MHz HE PPDU formats. The same structure as used for the 80 MHz HE PPDU formats is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz HE PPDU formats.

A 996-tone RU consists of 980 data subcarriers and 16 pilot subcarriers. The position of the pilots for the 996-tone RU is defined in 28.3.3.4 (Pilot subcarriers). The locations of the 996-tone RUs are fixed and located on subcarrier [−1012: −515, −509: −12] and [12: 509, 515: 1012] for each half of the BW, respectively, for 160 MHz and 80+80 MHz HE PPDU formats. A 2×996-tone RU consists of two 996-tone RUs, each located at each half of the PPDU bandwidth for 160 MHz and 80+80 MHz HE PPDU formats.

The 20 MHz HE MU PPDU and HE TB PPDU with one or more RUs smaller than 242 tones has 7 DC subcarriers located at [−3: 3]. The 20 MHz HE SU PPDU, HE MU PPDU and HE TB PPDU with a 242-tone RU has 3 DC subcarriers located at [−1: 1]. The 40 MHz HE PPDU has 5 DC subcarriers located at [−2: 2]. An 80 MHz HE MU PPDU and HE TB PPDU with one or more RUs smaller than 996 tones has 7 DC subcarriers located at [−3: 3]. The 80 MHz HE SU PPDU, HE MU PPDU and HE TB PPDU with a 996-tone RU has 5 DC subcarriers located at [−2: 2]. The same structure as used in the 80 MHz HE PPDU is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz HE PPDU. The DC tones are located on subcarriers [−11: 11].

The 20 MHz HE PPDU format has 11 guard subcarriers: the 6 leftmost subcarriers [−128: −123] and 5 rightmost subcarriers [123: 127] as shown in Figure 28-5 (RU locations in a 20 MHz HE PPDU). The 40 MHz HE PPDU has 23 guard subcarriers: the 12 leftmost subcarriers [−256: −245] and the 11 rightmost subcarriers [245: 255] as shown in Figure 28-6 (RU locations in a 40 MHz HE PPDU). The 80 MHz HE PPDU has 23 guard subcarriers: the 12 leftmost subcarriers [−512: −501] and the 11 rightmost subcarriers [501: 511] as shown in Figure 28-7 (RU locations in an 80 MHz HE PPDU). For 160 MHz and 80+80 MHz HE PPDUs, the same number of leftmost and rightmost guard subcarriers as 80 MHz are defined at each edge of the 160 MHz and 80+80 MHz.

In an HE MU PPDU, at least $N \times 4 \times 26$ subcarriers (contiguous or non-contiguous) shall be occupied throughout the signaled BW, where N is the number of 20 MHz subchannels occupied by non-HE portions of the HE PPDU preamble.

28.3.3.3 Null subcarriers

There are null subcarriers between the 26-, 52- and 106-tone RU locations as illustrated in Figure 28-5 (RU locations in a 20 MHz HE PPDU), Figure 28-6 (RU locations in a 40 MHz HE PPDU) and Figure 28-7 (RU locations in an 80 MHz HE PPDU). The null subcarriers are located near the DC or edge tones to protect

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those tones near the DC or edge tones from the interference of a neighboring RU. The null subcarriers have zero energy. The indices of the null subcarrier are enumerated in Table 28-9 (Null subcarrier indices).

Table 28-9— Null subcarrier indices

Channel Width	RU Size	Null Subcarrier Indices
20 MHz	26, 52	±69, ±122
	106	none
	242	none
40 MHz	26, 52	±3, ±56, ±57, ±110, ±137, ±190, ±191, ±244
	106	±3, ±110, ±137, ±244
	242, 484	none
80 MHz	26, 52	±17, ±70, ±71, ±124, ±151, ±204, ±205, ±258, ±259, ±312, ±313, ±366, ±393, ±446, ±447, ±500
	106	±17, ±124, ±151, ±258, ±259, ±366, ±393, ±500
	242, 484	none
	996	none

28.3.3.4 Pilot subcarriers

If pilot subcarriers are present in the HE-LTF field of an HE SU PPDU, HE MU PPDU, HE ER SU PPDU, or HE TB PPDU, the pilot subcarrier locations in the HE-LTF field and Data field shall be the same, except for the 1x HE-LTF and 2x HE-LTF. In a 1x HE-LTF, the pilot subcarrier locations in the HE-LTF only consist of the pilot subcarriers for the Data field that are multiples of four. If pilot subcarriers are present in a 2x HE-LTF, then their locations shall be the same as those pilots in a 4x data symbol. All pilot subcarriers are at the even indices enumerated in Table 28-10 (Pilot subcarrier indices).

Table 28-10— Pilot subcarrier indices

Channel Width	RU Size	Pilot Subcarrier Indices
20 MHz	26, 52	±10, ±22, ±36, ±48, ±62, ±76, ±90, ±102, ±116
	106, 242	±22, ±48, ±90, ±116
40 MHz	26, 52	±10, ±24, ±36, ±50, ±64, ±78, ±90, ±104, ±116, ±130, ±144, ±158, ±170, ±184, ±198, ±212, ±224, ±238
	106, 242, 484	±10, ±36, ±78, ±104, ±144, ±170, ±212, ±238
80 MHz	26, 52	±10, ±24, ±38, ±50, ±64, ±78, ±92, ±104, ±118, ±130, ±144, ±158, ±172, ±184, ±198, ±212, ±226, ±238, ±252, ±266, ±280, ±292, ±306, ±320, ±334, ±346, ±360, ±372, ±386, ±400, ±414, ±426, ±440, ±454, ±468, ±480, ±494
	106, 242, 484	±24, ±50, ±92, ±118, ±158, ±184, ±226, ±252, ±266, ±292, ±334, ±360, ±400, ±426, ±468, ±494
	996	±24, ±92, ±158, ±226, ±266, ±334, ±400, ±468

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Table 28-10— Pilot subcarrier indices *(continued)*

160 MHz	26, 52, 106, 242, 484	{pilot subcarrier indices in 80 MHz –512, pilot subcarrier indices in 80 MHz +512}
	996	{for the lower 80 MHz, pilot subcarrier indices in 80 MHz –512, for the upper 80 MHz, pilot subcarrier indices in 80 MHz +512}

The pilot subcarriers locations for 160 MHz or 80+80 MHz shall use the same 80 MHz locations for both 80 MHz.

28.3.3.5 20 MHz operating non-AP HE STAs

A 20 MHz-only non-AP HE STA is a non-AP HE STA that indicates in the Channel Width Set subfield in the HE PHY Capabilities Information field of the HE Capabilities element that it transmits (see 9.4.2.237.3 (HE PHY Capabilities Information field)), support for only 20 MHz channel width for the frequency band in which it is operating. A 20 MHz operating non-AP HE STA is a non-AP HE STA that is operating in 20 MHz channel width mode, such as a 20 MHz-only non-AP HE STA or an HE STA that reduced its operating channel width to 20 MHz using operating mode indication (OMI).

A 20 MHz operating non-AP HE STA shall operate in the primary 20 MHz channel.

An HE AP in 5 GHz shall be able to interoperate with non-AP HE STAs, regardless of the indicated value of B1 in the Channel Width Set subfield in the HE PHY Capabilities Information field in the HE Capabilities element (see 9.4.2.237.3 (HE PHY Capabilities Information field)).

A 20 MHz operating non-AP HE STA shall support tone mapping of 26-tone RU, 52-tone RU, 106-tone RU and 242-tone RU for a 20 MHz HE PPDU (see Table 28-6 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU)) in the 2.4 GHz and 5 GHz frequency bands.

A 20 MHz operating non-AP HE STA indicates support of tone mapping of 26-tone RU, 52-tone RU, and 106-tone RU for a 40 MHz HE PPDU (see Table 28-7 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU)) in the 2.4 GHz frequency band in the 20 MHz In 40 MHz HE PPDU In 2.4 GHz Band subfield in the HE PHY Capabilities Information field in the HE Capabilities element (see 9.4.2.237.3 (HE PHY Capabilities Information field)).

A 20 MHz operating non-AP HE STA shall support tone mapping of 26-tone RU, 52-tone RU, and 106-tone RU, for 40 MHz HE PPDU (see Table 28-7 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU)) in the 5 GHz frequency band, and for 80 MHz HE PPDU (see Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU)) in the 5 GHz frequency band with the exception of RUs that are restricted from operation as specified in 28.3.3.6 (RU restrictions for 20 MHz operation).

A 20 MHz operating non-AP HE STA indicates support of tone mapping of 26-tone RU, 52-tone RU, and 106-tone RU for 80+80 MHz and 160 MHz HE PPDU in the 20 MHz In 160 MHz HE PPDU subfield in the HE PHY Capabilities Information field in the HE Capabilities element (see 9.4.2.237.3 (HE PHY Capabilities Information field)).

A 20 MHz operating non-AP HE STA may support tone mapping of 242-tone RU, for the reception of 40 MHz HE MU PPDU (see Table 28-7 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU)) in the 2.4 GHz and 5 GHz frequency bands, and 80 MHz, 80+80 MHz and 160 MHz HE MU PPDU (see Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU)) in the 5 GHz frequency

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band.This support is indicated in the Channel Width Set subfield in the HE PHY Capabilities Information field of the HE Capabilities element (see 9.4.2.237.3 (HE PHY Capabilities Information field)).

28.3.3.6 RU restrictions for 20 MHz operation

When a 20 MHz operating non-AP HE STA is the receiver of a 40 MHz, 80 MHz, 80+80 MHz or 160 MHz HE MU PPDU, or the transmitter of a 40 MHz, 80 MHz, 80+80 MHz or 160 MHz HE TB PPDU, then the RU tone mapping in 20 MHz is not aligned with the 40 MHz, 80 MHz, 80+80 MHz or 160 MHz RU tone mapping (see 28.3.3.2 (Resource unit, guard and DC subcarriers)).

An AP shall not assign the following RUs to a 20 MHz operating non-AP HE STA:

- 26-tone RU 5 and 14 of a 40 MHz HE MU PPDU and HE TB PPDU
- 26-tone RU 5, 10, 14, 19, 24, 28 and 33 of an 80 MHz HE MU PPDU and HE TB PPDU
- 26-tone RU 5, 10, 14, 19, 24, 28 and 33 of the lower 80 MHz or upper 80 MHz of an 80+80 MHz and 160 MHz HE MU PPDU
- 26-tone RU 5, 10, 14, 19, 24, 28 and 33 of the lower 80 MHz or upper 80 MHz of an 80+80 MHz and 160 MHz HE TB PPDU
- 52-tone RU 5 and 12 of an 80 MHz HE MU PPDU or HE TB PPDU
- 52-tone RU 5 and 12 of the lower 80 MHz or upper 80 MHz of an 80+80 MHz and 160 MHz HE MU PPDU
- 106-tone RU 3 and 6 of an 80 MHz HE MU PPDU and HE TB PPDU
- 106-tone RU 3 and 6 of the lower 80 MHz or upper 80 MHz of an 80+80 MHz and 160 MHz HE MU PPDU
- 106-tone RU 3 and 6 of the lower 80 MHz or upper 80 MHz of an 80+80 MHz and 160 MHz HE TB PPDU

The center 26-tone RU in the primary 20 MHz channel shall not be assigned to a non-AP STA when 20 MHz operating non-AP HE STAs are recipients of a 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz HE MU PPDU.

It is optional whether all 242-tone RUs of non-AP STAs with 20 MHz operating channel width to be supported in 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz HE MU PPDU, and it is indicated in the Channel Width Set subfield in the HE PHY Capabilities Information field of the HE Capabilities element (see 9.4.2.237.3 (HE PHY Capabilities Information field)). A 242-tone RU for a 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz HE TB PPDU shall not be allocated to a 20 MHz operating non-AP HE STA.

28.3.3.7 80 MHz operating non-AP HE STAs

A non-AP HE STA capable of up to 80 MHz channel width, when operating with 80 MHz channel width, indicates support of reception of 160 MHz or 80+80 MHz HE MU PPDU, or the transmission of 160 MHz or 80+80 MHz HE TB PPDU in the 80 MHz In 160/80+80 MHz HE PPDU subfield in the HE PHY Capabilities Information field in the HE Capabilities element (see 9.4.2.237.3 (HE PHY Capabilities Information field)).

An HE AP STA shall not allocate RUs outside of the primary 80 MHz when allocating an RU in an 160 MHz or 80+80 MHz HE MU PPDU or HE TB PPDU to a non-AP HE STA that sets the 80 MHz In 160/80+80 MHz HE PPDU subfield in the HE PHY Capabilities Information field in the HE Capabilities element to 1 and is operating in 80 MHz channel width mode.

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28.3.3.8 DL MU transmission

DL MU transmission allows an AP to simultaneously transmit to more than one non-AP STA. The AP uses the HE MU PPDU for DL MU transmission.

28.3.3.9 DL MU-MIMO

28.3.3.9.1 Supported RU sizes in DL MU-MIMO

A STA that sets the Partial Bandwidth DL MU-MIMO subfield of the HE PHY Capabilities Information field in the HE Capabilities element that it transmits to 1 shall support reception of an HE MU PPDU with RU sizes greater than or equal to 106 subcarriers.

28.3.3.9.2 Maximum number of spatial streams in an HE MU PPDU

An HE STA shall support the reception of DL MU-MIMO transmissions on full bandwidth with a maximum number of space-time streams (per user) that is the minimum of 4 and the maximum number of space-time streams supported for reception of HE SU PPDUs. The maximum number of space-time streams supported for reception of HE SU PPDUs is indicated for various bandwidths in Supported HE-MCS and NSS Set field in the HE Capabilities element.

An HE STA shall support reception of DL MU-MIMO transmissions on full bandwidth with the total number of space-time streams (across NUM_USERS) less than or equal to a maximum value indicated by the Beamformee STS ≤ 80 MHz and Beamformee STS > 80 MHz subfields in the HE PHY Capabilities Information field in the HE Capabilities element.

An HE AP that is capable of transmitting 4 or more space-time streams shall support DL MU-MIMO transmissions on full bandwidth.

All of the aforementioned restrictions in this subclause on the per-user and total number of space-time-streams are also applicable to an MU-MIMO transmission on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth.

28.3.3.9.3 Resource indication and User identification in an HE MU PPDU

An AP that transmits an HE MU PPDU shall set the UL/DL field in the HE-SIG-A field to 0.

A full bandwidth MU-MIMO transmission using the HE MU PPDU format has a value of 1 for the SIGB Compression field in HE-SIG-A and the Common field in HE-SIG-B is not present, and the HE modulated fields of the PPDU consists of one RU whose size spans the entire PPDU bandwidth. The number of users in the MU-MIMO group is indicated in the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in HE-SIG-A. The allocated spatial streams for each user and the total number of spatial streams are indicated in the Spatial Configuration field of User field in HE-SIG-B containing the STA-ID of designated MU-MIMO STA as defined in Table 28-27 (Spatial Configuration field encoding).

If the value of SIGB Compression field in HE-SIG-A is 0, then the RU Allocation subfield in the Common field in each HE-SIG-B content channel indicates the combination of RUs in the current PPDU and the number of User fields included in the corresponding HE-SIG-B content channel for each RU. See 28.3.10.8.2 (Encoding and modulation) for a description of the HE-SIG-B content channel.

A 20 MHz HE MU PPDU has one HE-SIG-B content channel, while an HE MU PPDU with greater than 20 MHz PPDU bandwidth has two HE-SIG-B content channels. In each HE-SIG-B content channel, the number of spatial streams for a user in an RU is indicated by the NSTS field in the User field if there is only

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one User field (see Table 28-25 (User field for a non-MU-MIMO allocation)) corresponding to the RU in the HE-SIG-B content channel.

If there are more than one User fields (see Table 28-26 (User field for an MU-MIMO allocation)) for an RU in the HE-SIG-B content channel, the number of allocated spatial streams for each user in the RU are indicated by the Spatial Configuration field of the User field in HE-SIG-B. Note that an RU with RU size greater than or equal to 484 subcarriers and having two or more intended users, the User fields corresponding to the RU may split between two HE-SIG-B content channels. In this case, the total number of users and the total number of spatial streams in the RU are the sum of the number of users and number of spatial streams per user, respectively, indicated in both HE-SIG-B content channels. In case of full bandwidth DL MU-MIMO with PPDU bandwidth greater than 20 MHz, see 28.3.10.8.6 (HE-SIG-B per-user content) on further details on how the User fields are split between the two HE-SIG-B content channels.

In each HE-SIG-B content channel, the User fields are first ordered in the order of RUs (from lower frequency to higher frequency) as described by the RU Allocation field if the HE-SIG-B contains the Common field. If an RU has multiple User fields in an HE-SIG-B content channel, the User fields of the RU are ordered in the order of spatial stream index, from lower to higher spatial stream, as indicated in the Spatial Configuration field. The STA-ID field in each User field indicates the intended recipient user of the corresponding spatial streams and the RU.

HE-LTF symbols in the DL HE MU PPDU are used to measure the channel for the space-time streams intended for the STA and can also be used to measure the channel for the interfering space-time streams. To successfully demodulate the space-time streams intended for the STA, it is recommended that the STA uses the channel knowledge for all space-time streams to reduce the effect of interfering space-time streams.

If a STA is included as a member of the MU-MIMO group in RU r, its corresponding $N_{STS,r,u}$ contained in the User field in HE-SIG-B shall not be zero. If a STA finds that it is not a member of the MU-MIMO group in RU r, then the STA may elect not to process RU r in the remainder of the PPDU.

28.3.3.10 UL MU transmission

UL MU transmissions allow an AP to receive simultaneous frames from more than one non-AP STA. UL MU transmissions for UL MU-MIMO and UL OFDMA are preceded by a Trigger frame from the AP. The non-AP STA(s) use the HE TB PPDU for UL MU transmission.

28.3.3.11 UL MU-MIMO

28.3.3.11.1 Introduction

UL MU-MIMO is a technique to allow multiple STAs to transmit simultaneously over the same frequency resource to the receiver. The concept is very similar to SU-MIMO where multiple space-time streams are transmitted simultaneously over the same frequency resource utilizing spatial multiplexing through multiple antennas at the transmitter and receiver. The key difference from SU-MIMO is that in UL MU-MIMO, the transmitted streams originate from multiple STAs.

28.3.3.11.2 Supported RU sizes in UL MU-MIMO

A STA that sets the Partial Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field in the HE Capabilities element that it transmits to 1 shall support transmission and reception of an HE TB PPDU with RU sizes greater than or equal to 106 subcarriers.

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28.3.3.11.3 MU-MIMO LTF Mode

A STA that sets the Full Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field in the HE Capabilities element it transmits to 1 shall support HE single stream pilot HE LTF mode and HE masked HE LTF sequence mode as defined in Equation (28-52).

A STA that sets the Partial Bandwidth UL MU-MIMO subfield of the HE PHY Capabilities Information field in the HE Capabilities element it transmits to 1 shall support HE single stream pilot HE LTF mode for any UL OFDMA transmission, including UL OFDMA with MU-MIMO transmission on an RU in an HE TB PPDU.

28.3.3.11.4 Maximum number of spatial streams in UL MU-MIMO

A STA that supports UL MU-MIMO transmission shall support UL MU-MIMO transmissions on full bandwidth with a maximum number of space-time streams (per user) that is the minimum of 4 and the maximum number of space-time streams supported for transmission of HE SU PPDUs. The maximum number of space-time streams supported for transmission of HE SU PPDUs is indicated for various bandwidths in Supported HE-MCS and NSS Set field in the HE Capabilities element.

A STA that supports UL MU-MIMO transmission on full bandwidth supports a total of up to 8 space-time streams.

All of the aforementioned restrictions in this subclause on the per-user and total number of space-time-streams are also applicable to an MU-MIMO transmission on an RU in an HE MU PPDU where the RU does not span the entire PPDU bandwidth.

28.3.3.11.5 Resource allocation for an HE TB PPDU

UL MU transmissions are preceded by a Trigger frame from the AP. The Common Info field of the Trigger frame indicates to the STAs performing the UL MU transmissions when to transmit, and the duration of the payload and packet extension. The GI duration for UL MU transmissions shall also be explicitly indicated by AP in the Trigger frame. The value of GI duration for all users addressed by the Trigger frame shall be the same. The Trigger frame indicates whether the UL MU transmission following it uses HE single stream pilot HE LTF mode or HE masked HE LTF sequence mode or no pilots if a 1x LTF is used. When HE single stream pilot HE LTF mode is used, no masking is applied to the HE-LTF. HE single stream pilot HE LTF mode is used for any UL OFDMA transmission, including UL OFDMA with MU-MIMO transmissions. The appropriate MU-MIMO LTF mode indicated by the Trigger frame is used for full bandwidth UL MU-MIMO transmission except for 1x LTF. The allocated RU and spatial streams are carried in the RU Allocation subfield and SS Allocation subfield of the User Info field that has the AID12 subfield set as the AID of designated MU-MIMO STA.

If a STA finds that there is no User Info field in the Trigger frame carrying the STA's AID in the AID12 subfield and there is no resource allocated for random access, then the STA shall not transmit in the following HE TB PPDU.

28.3.4 HE PPDU formats

Four HE PPDU formats are defined: HE SU PPDU, HE MU PPDU, HE ER SU PPDU and HE TB PPDU.

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The format of the HE SU PPDU is defined as in Figure 28-8 (HE SU PPDU format). This PPDU format is used for SU transmission and, in this format, the HE-SIG-A field is not repeated.

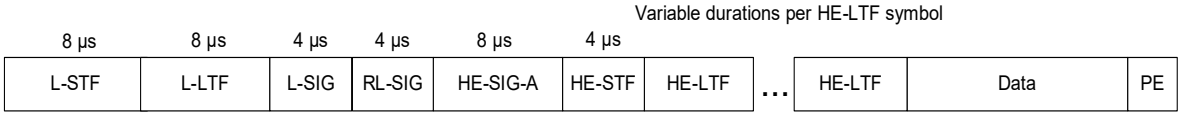


Figure 28-8—HE SU PPDU format

The format of the HE MU PPDU is defined as in Figure 28-9 (HE MU PPDU format). This format is used for transmission to one or more users when the PPDU is not a response of a Trigger frame. The HE-SIG-B field is present in this format.

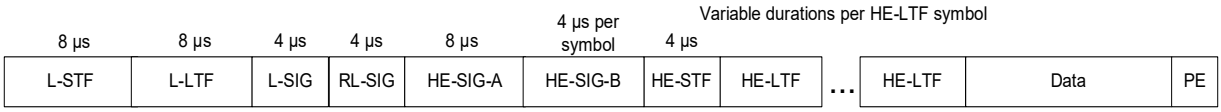


Figure 28-9—HE MU PPDU format

The format of the HE ER SU PPDU is defined as in Figure 28-10 (HE ER SU PPDU format). This format is used for SU transmission and, in this format, the HE-SIG-A field is twice as long as for other formats.

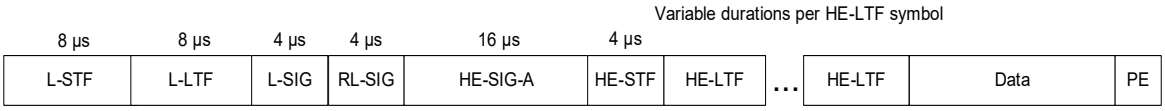


Figure 28-10—HE ER SU PPDU format

The format of the HE TB PPDU is defined as in Figure 28-11 (HE TB PPDU format). This format is used for a transmission that is a response to a Trigger frame. The HE TB PPDU format is identical to the HE SU PPDU format for the L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A fields. The duration of the HE-STF field is 8 µs.

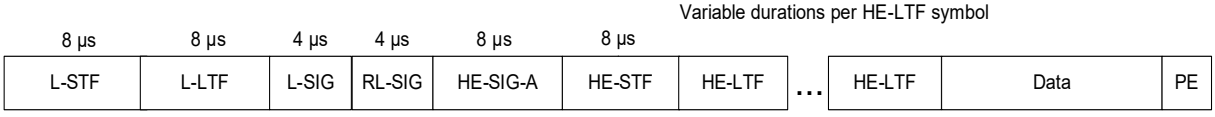


Figure 28-11—HE TB PPDU format

The fields of the HE PPDU formats are summarized in Table 28-11 (HE PPDU fields).

Table 28-11—HE PPDU fields

Field	Description
L-STF	Non-HT Short Training field

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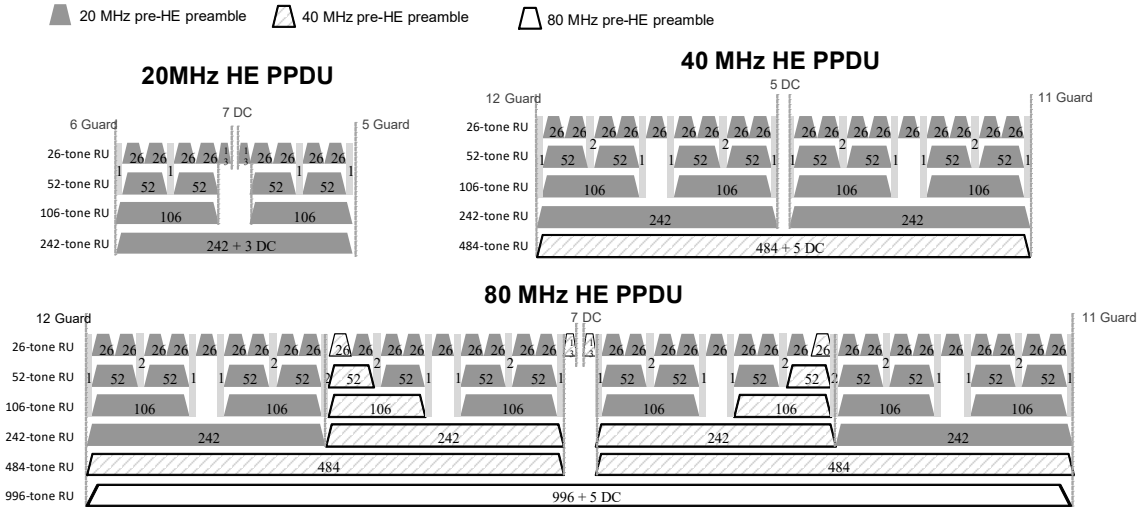
Table 28-11—HE PPDU fields *(continued)*

L-LTF	Non-HT Long Training field
L-SIG	Non-HT SIGNAL field
RL-SIG	Repeated Non-HT SIGNAL field
HE-SIG-A	HE SIGNAL A field
HE-SIG-B	HE SIGNAL B field
HE-STF	HE Short Training field
HE-LTF	HE Long Training field
Data	The Data field carrying the PSDU(s)
PE	Packet Extension field

The RL-SIG, HE-SIG-A, HE-STF, HE-LTF, and PE fields are present in all HE PPDU formats. The HE-SIG-B field is present only in the HE MU PPDU. The duration of the PE field is given in 28.3.12 (Packet extension).

The L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A, and HE-SIG-B fields are referred to as the Pre-HE modulated fields, while the HE-STF, HE-LTF and Data fields are referred to as the HE modulated fields.

In the HE TB PPDU, the pre-HE modulated fields, which include L-STF, L-LTF, L-SIG, RL-SIG and HE-SIG-A fields, are sent only on the 20 MHz channels where the STA's HE modulated fields are located. When the HE modulated fields are located in more than one 20 MHz channel, the pre-HE modulated fields are duplicated over the multiple 20 MHz channels, as shown in Figure 28-12 (Pre-HE modulated fields in an HE TB PPDU).



The 160 MHz and 80+80 MHz HE PPDU uses the 80 MHz HE PPDU RU locations in each 80 MHz frequency segment

Figure 28-12—Pre-HE modulated fields in an HE TB PPDU

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Transmissions of frames with TXVECTOR parameter NO_SIG_EXTN equal to false are followed by a period of no transmission for a duration of aSignalExtension. See 10.3.8 (Signal Extension).

A Signal Extension shall be present in a transmitted PPDU, based on the parameters of the TXVECTOR, when the NO_SIG_EXTN parameter is equal to false and either of the following is true:

— The FORMAT parameter is equal to HE

— The FORMAT parameter is equal to NON_HT, and the NON_HT_MODULATION parameter is equal to NON_HT_DUP_OFDM

A Signal Extension shall be assumed to be present (for the purpose of timing of PHY-RXEND.indication and PHY-CCA.indication primitives, as described below and in 28.3.21 (HE receive procedure)) in a received PPDU when either of the following is true, based on the determined parameter values of the RXVECTOR:

— The FORMAT parameter is equal to HE

— The FORMAT parameter is equal to NON_HT, and the NON_HT_MODULATION parameter is equal to NON_HT_DUP_OFDM

A PPDU containing a signal extension is called a signal extended PPDU. When transmitting a signal extended PPDU, the PHY-TXEND.indication primitive shall be emitted a period of aSignalExtension after the end of the actual ending time of the PPDU. When receiving a signal extended PPDU, the PHYRX-END.indication primitive shall be emitted a period of aSignalExtension after the end of the actual ending time of the PPDU.

28.3.5 Transmitter block diagram

The generation of each field in an HE PPDU uses many of the following blocks:

a) pre-FEC PHY padding
b) Scrambler
c) FEC (BCC or LDPC) encoders
d) post-FEC PHY padding
e) Stream parser
f) Segment parser (for contiguous 160 MHz and noncontiguous 80+80 MHz transmissions)
g) BCC interleaver
h) Constellation mapper
i) DCM tone mapper
j) Pilot insertion
k) Replication over multiple 20 MHz (for BW > 20 MHz)
l) Multiplication by 1st column of $P_{HE\text{-}LTF}$
m) LDPC tone mapper
n) Segment deparser
o) Space time block code (STBC) encoder
p) Cyclic shift diversity (CSD) per STS insertion
q) Spatial mapper
r) Frequency mapping
s) Inverse discrete Fourier transform (IDFT)
t) Cyclic shift diversity (CSD) per chain insertion
u) Guard interval (GI) insertion

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v) Windowing

Figure 28-13 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE ER SU PPDU when the Beam Change field is 1 and the HE MU PPDU) to Figure 28-21 (Transmitter block diagram for the Data field of an HE SU PPDU in 80+80 MHz with LDPC encoding) show example transmitter block diagrams. The actual structure of the transmitter is implementation dependent.

In particular, Figure 28-13 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE ER SU PPDU when the Beam Change field is 1 and the HE MU PPDU) shows the transmit process for the L-SIG, RL-SIG, and HE-SIG-A fields of an HE PPDU using one frequency segment, when the Beam Change subfield in HE-SIG-A field is set to 1. These transmit blocks are also used to generate the L-STF and L-LTF fields of the HE PPDU when the Beam Change subfield in HE-SIG-A field is set to 1, with the following exceptions:

— The BCC encoder and interleaver as well as constellation mapper are not used when generating the L-STF and L-LTF fields.

— The BCC interleaver is not applied in the repeated HE-SIG-A symbols (i.e. the 2nd and the 4th OFDM symbols of HE-SIG-A field) in the HE ER SU PPDU.

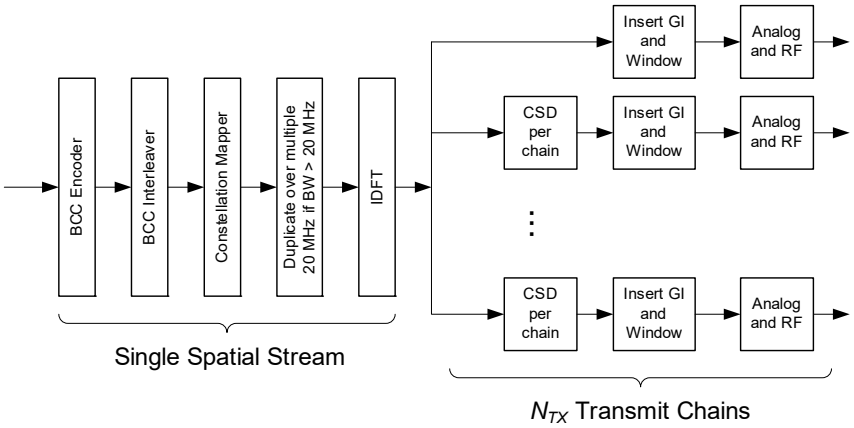


Figure 28-13—Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE ER SU PPDU when the Beam Change field is 1 and the HE MU PPDU

Figure 28-14 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE ER SU PPDU when the Beam Change field is 0) shows the transmit process for the L-SIG, RL-SIG, and HE-SIG-A fields of an HE PPDU using one frequency segment, when the Beam Change subfield in HE-SIG-A field is set to 0. These transmit blocks are also used to generate the L-STF and L-LTF fields of the HE PPDU when the Beam Change subfield in HE-SIG-A field is set to 0, with the following exceptions:

— The BCC encoder and interleaver as well as constellation mapper are not used when generating the L-STF and L-LTF fields.

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— The BCC interleaver is not applied in the repeated HE-SIG-A field OFDM symbols (i.e., the 2nd and the 4th OFDM symbols of HE-SIG-A field) in the HE ER SU PPDU.

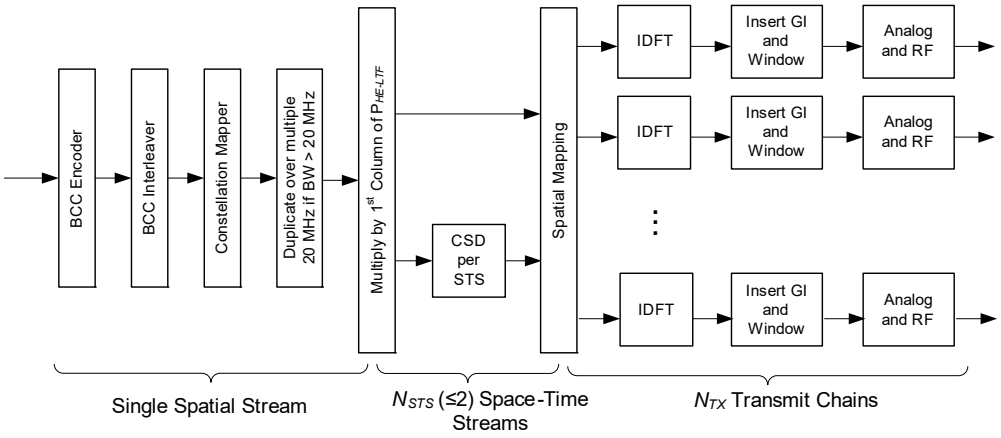


Figure 28-14—Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields for an HE SU PPDU and HE ER SU PPDU when the Beam Change field is 0

Figure 28-15 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields of an HE TB PPDU) shows the transmit process for the L-SIG, RL-SIG and HE-SIG-A fields of an HE TB PPDU using one frequency segment. In the HE TB PPDU, the transmission of the pre-HE modulated fields refer to the description in 28.3.4 (HE PPDU formats) and also shown in Figure 28-15 (Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields of an HE TB PPDU). The BCC encoder and interleaver are not used when generating the L-STF and L-LTF fields.

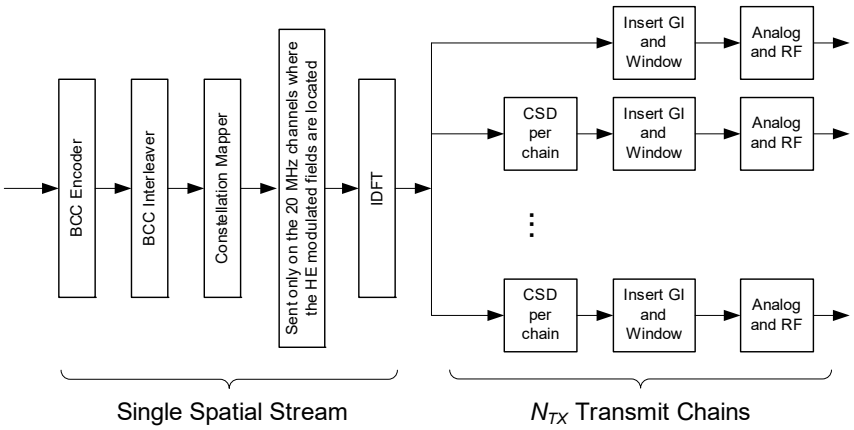


Figure 28-15—Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields of an HE TB PPDU

Figure 28-16 (Transmitter block diagram for the HE-SIG-B field) shows the transmit process for the HE-SIG-B field of an HE MU PPDU using one frequency segment. This block diagram is for transmitting HE-SIG-B in one 20 MHz subchannel. Refer to 28.3.10.8.2 (Encoding and modulation) for the methods of trans-

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mitting HE-SIG-B in 40 MHz, 80 MHz and 160 MHz. The DCM tone mapper is applied only if the DCM indication in HE-SIG-A field is set to 1.

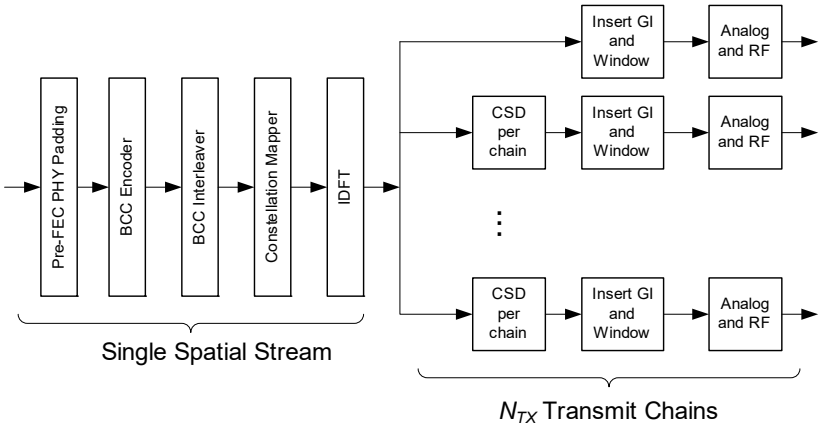


Figure 28-16—Transmitter block diagram for the HE-SIG-B field

Figure 28-17 (Transmitter block diagram for the Data field of an HE SU transmission in a 26-, 52-, 106- or 242-tone RU with BCC encoding) shows the transmitter blocks used to generate the Data field of a single user HE transmission within a 26-, 52-, 106-, or 242-tone RU with BCC encoding for a single frequency segment when the number of spatial streams is less than or equal to 4. This includes the SU transmission in an RU that is part of a downlink or uplink HE PPDU using OFDMA transmission, and a transmission from one STA that is part of an UL MU-MIMO transmission in current RU. The STBC block is applied only for a single spatial stream transmission and only when DCM is not applied. The DCM tone mapper is applied only when the DCM indication for the RU is set to 1. A subset of these transmitter blocks consisting of the constellation mapper and CSD blocks, as well as the blocks to the right of, and including, the spatial mapping block, are also used to generate the HE-LTF fields. This is illustrated in Figure 28-31 (Generation of HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU, HE ER SU PPDU and HE TB PPDU). A subset of these transmitter blocks consisting of the constellation mapper and CSD blocks, as well as the blocks to the right of, and including, the spatial and frequency mapping block of Figure 28-17 (Transmitter block diagram for the Data field of an HE SU transmission in a 26-, 52-, 106- or 242-tone RU with

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BCC encoding), are also used to generate the HE-STF field. This figure also applies to the Data field with BCC encoding in an HE TB PPDU.

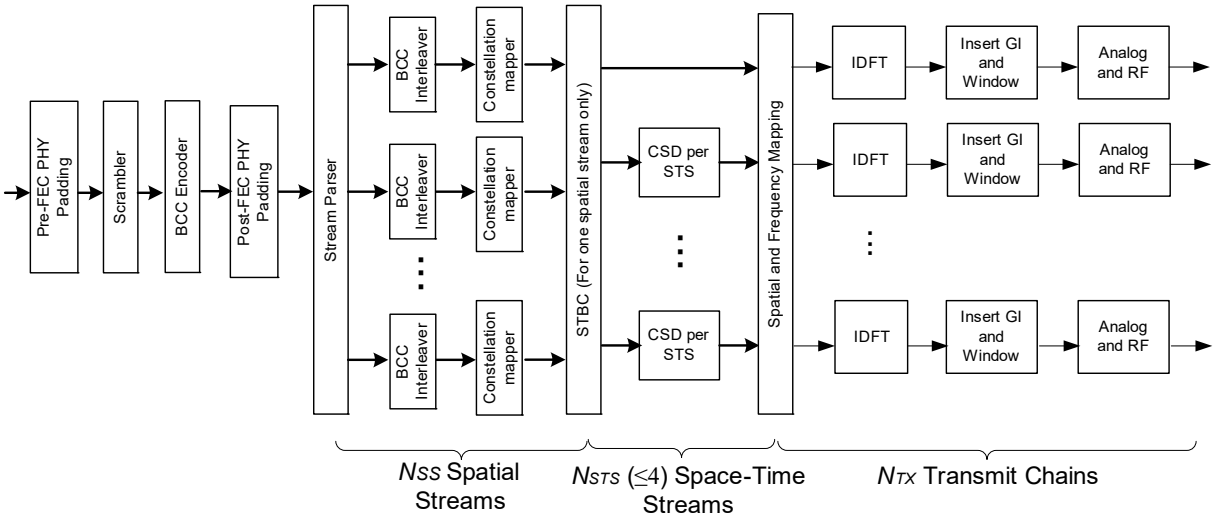


Figure 28-17—Transmitter block diagram for the Data field of an HE SU transmission in a 26-, 52-, 106- or 242-tone RU with BCC encoding

Figure 28-18 (Transmitter block diagram for the Data field of an HE SU transmission in 26-, 52-, 106-, 242-, 484- or 996-tone RU with LDPC encoding) shows the transmitter blocks used to generate the Data field of a single user HE transmission within a 26-, 52-, 106-, 242-, 484-, or 996-tone RU with LDPC encoding for a single frequency segment. This also includes the SU transmission in an RU that is part of a downlink or uplink OFDMA PPDU, and a transmission from one STA that is part of an UL MU-MIMO transmission in current RU. The STBC block may be applied only for single spatial stream and only when DCM is not

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applied. The DCM tone Mapper is applied only when the DCM indication for the RU is set to 1. This figure also applies to the data field with LDPC encoding in an HE TB PPDU.

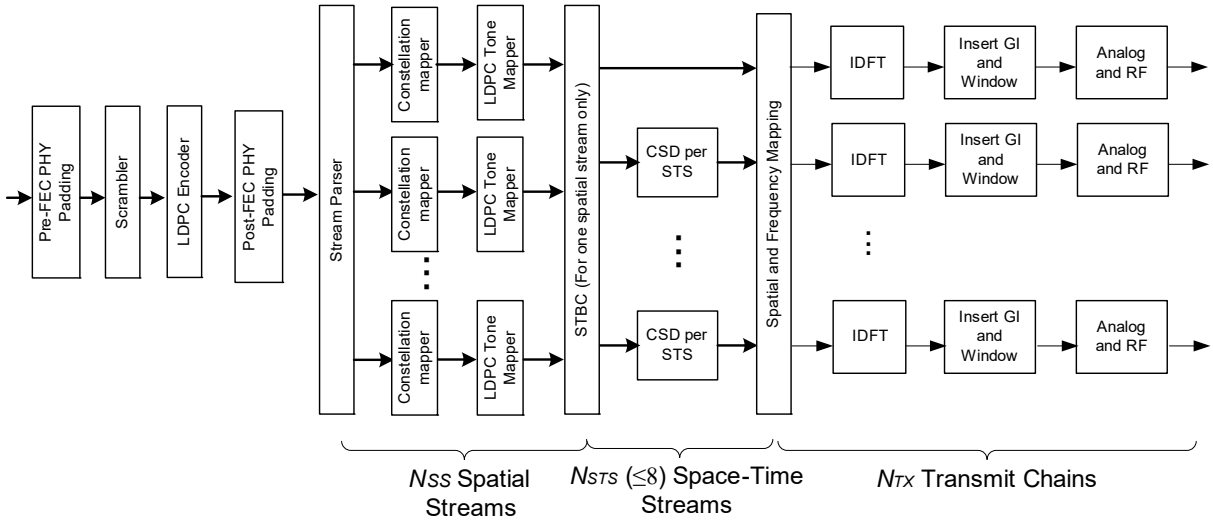


Figure 28-18—Transmitter block diagram for the Data field of an HE SU transmission in 26-, 52-, 106-, 242-, 484- or 996-tone RU with LDPC encoding

Figure 28-19 (Transmitter block diagram for the Data field of an HE downlink MU-MIMO transmission in 106-, 242-, 484- or 996-tone RU with LDPC encoding) shows the transmitter blocks used to generate the Data field of an HE downlink MU-MIMO transmission within a 106-, 242-, 484-, or 996-tone RU with

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LDPC encoding. This also includes the downlink MU-MIMO transmission in an RU that is part of a downlink OFDMA PPDU.

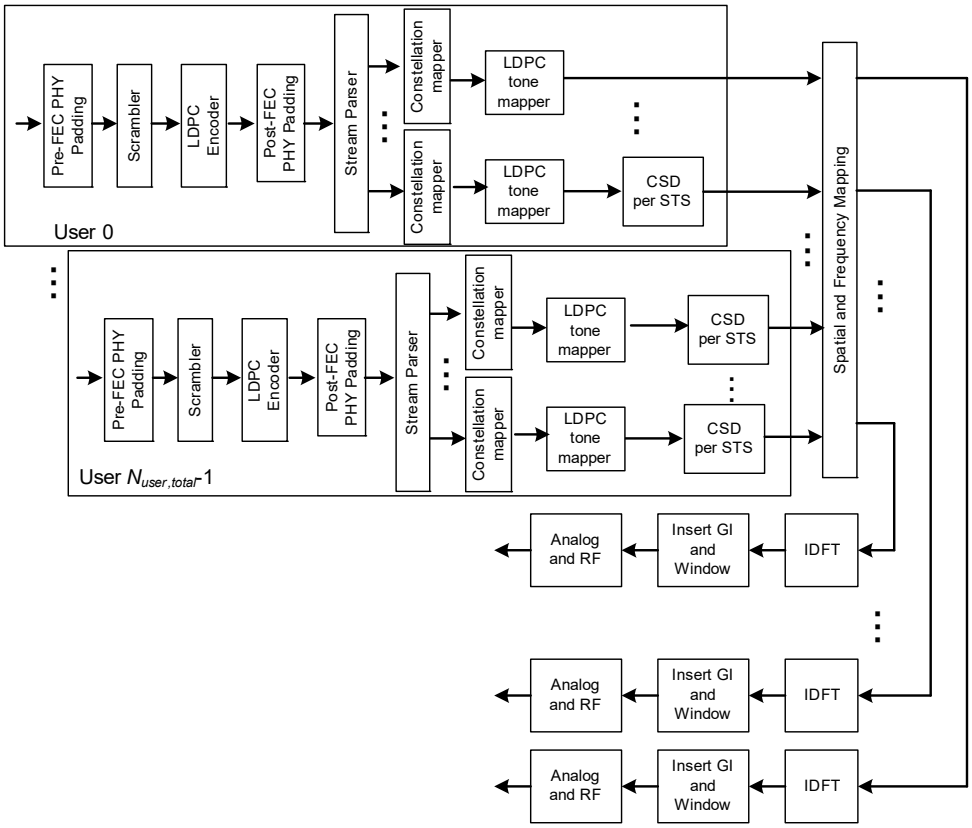


Figure 28-19—Transmitter block diagram for the Data field of an HE downlink MU-MIMO transmission in 106-, 242-, 484- or 996-tone RU with LDPC encoding

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Figure 28-20 (Transmitter block diagram for the Data field of an HE SU PPDU in 160 MHz with LDPC encoding) shows the transmitter blocks used to generate the Data field of a single-user HE transmission in 160 MHz with LDPC encoding.

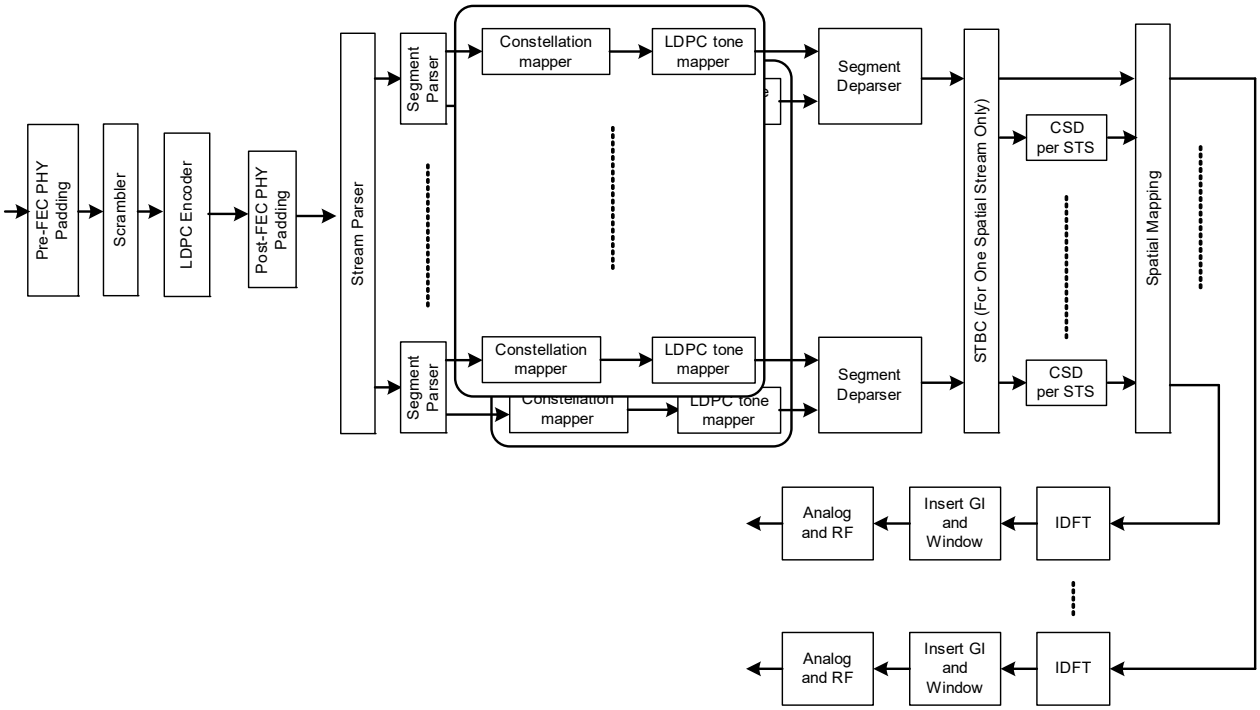


Figure 28-20—Transmitter block diagram for the Data field of an HE SU PPDU in 160 MHz with LDPC encoding

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Figure 28-21 (Transmitter block diagram for the Data field of an HE SU PPDU in 80+80 MHz with LDPC encoding) shows the transmitter blocks used to generate the Data field of a single-user HE transmission in 80+80 MHz with LDPC encoding.

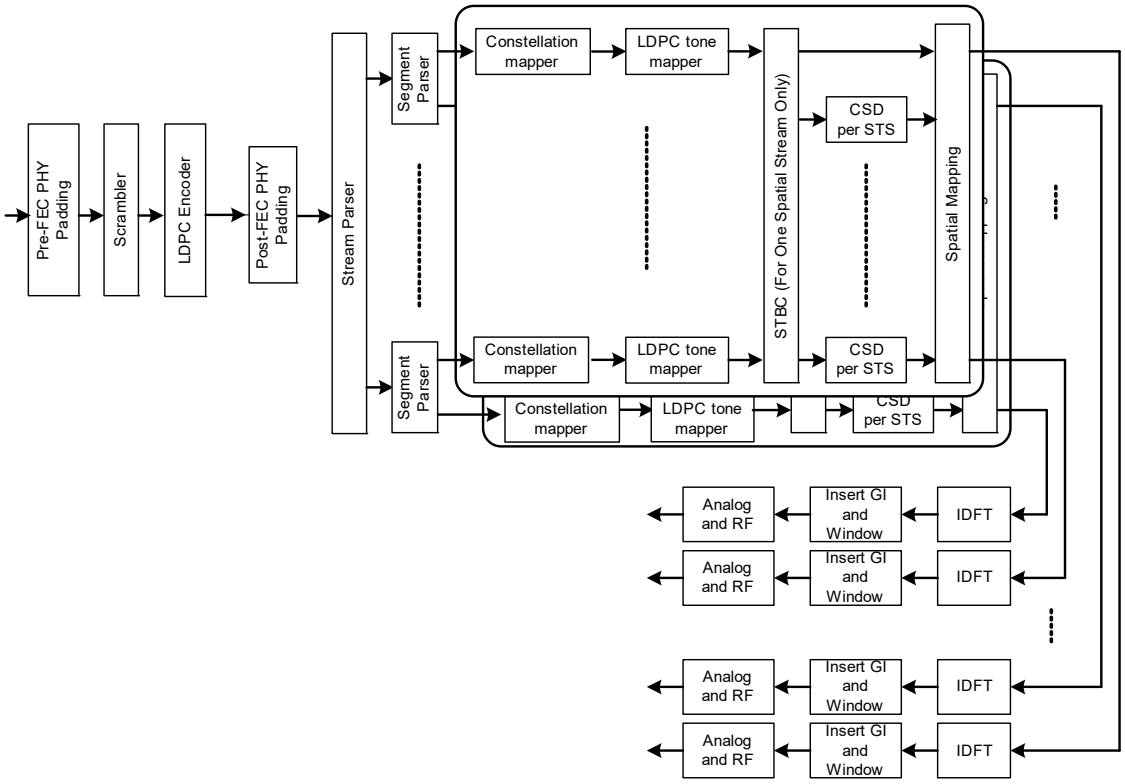


Figure 28-21—Transmitter block diagram for the Data field of an HE SU PPDU in 80+80 MHz with LDPC encoding

28.3.6 Overview of the PPDU encoding process

28.3.6.1 General

This subclause provides an overview of the HE PPDU encoding process.

28.3.6.2 Construction of L-STF

Construct the L-STF field as defined in 28.3.10.3 (L-STF) with the following highlights:

a) Determine the channel bandwidth from the TXVECTOR parameter CH_BANDWIDTH.

b) Sequence generation: Generate the L-STF sequence over the channel bandwidth as described in 28.3.10.3 (L-STF). Apply a 3 dB power boost if transmitting an HE ER SU PPDU as described in 28.3.10.3 (L-STF).

c) Phase rotation: Apply appropriate phase rotation for each 20 MHz subchannel as described in 28.3.9 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

d) CSD: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD for each space-time stream and frequency segment as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields).

e) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the A matrix and the Q matrix as described in 28.3.10.3 (L-STF).

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f) IDFT: Compute the inverse discrete Fourier transform.

g) CSD: If the TXVECTOR parameter BEAM_CHANGE is 1, apply CSD for each transmit chain and frequency segment as described in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

h) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{Pre-HE}}$) and apply windowing as described in 28.3.9 (Mathematical description of signals).

i) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.

28.3.6.3 Construction of L-LTF

Construct the L-LTF field as defined in 28.3.10.4 (L-LTF) with the following highlights:

a) Determine the channel bandwidth from the TXVECTOR parameter CH_BANDWIDTH.

b) Sequence generation: Generate the L-LTF sequence over the channel bandwidth as described in 28.3.10.4 (L-LTF). Apply a 3 dB power boost if transmitting an HE ER SU PPDU as described in 28.3.10.4 (L-LTF).

c) Phase rotation: Apply appropriate phase rotation for each 20 MHz subchannel as described in 28.3.9 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

d) CSD: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD for each space-time stream and frequency segment as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields) before spatial mapping.

e) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the A matrix and the Q matrix as described in 28.3.10.4 (L-LTF).

f) IDFT: Compute the inverse discrete Fourier transform.

g) CSD: If the TXVECTOR parameter BEAM_CHANGE is 1, apply CSD for each transmit chain and frequency segment as described in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

h) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{L-LTF}}$) and apply windowing as described in 28.3.9 (Mathematical description of signals).

i) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the carrier frequency of the desired channel and transmit. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.

28.3.6.4 Construction of L-SIG

Construct the L-SIG field as the SIGNAL field defined in 28.3.10.5 (L-SIG) with the following highlights:

a) Set the RATE subfield in the SIGNAL field to 6 Mb/s. Set the Length, Parity, and Tail bits in the SIGNAL field as described in 28.3.10.5 (L-SIG).

b) BCC encoder: Encode the SIGNAL field by a convolutional encoder at the rate of R = ½ as described in 28.3.11.5.1 (Binary convolutional coding and puncturing).

c) BCC interleaver: Interleave as described in 17.3.5.7 (BCC interleavers).

d) Constellation Mapper: BPSK modulate as described in 28.3.11.9 (Constellation mapping).

e) Pilot insertion: Insert pilots as described in 28.3.10.5 (L-SIG).

f) Extra tone insertion: Four extra tones are inserted in subcarriers $k \in \{-28, -27, 27, 28\}$ for channel estimation purpose and the values on these four extra tones are $\{-1, -1, -1, 1\}$, respectively. Apply a 3 dB power boost to the four extra tones if transmitting an HE ER SU PPDU as described in 28.3.10.5 (L-SIG).

g) Duplication and phase rotation: Duplicate the L-SIG field over each 20 MHz subchannel of the channel bandwidth. Apply appropriate phase rotation for each 20 MHz subchannel as described in 28.3.9 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

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h) CSD: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD for each space-time stream and frequency segment as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields) before spatial mapping.

i) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the A matrix and Q matrix as described in 28.3.10.5 (L-SIG).

j) IDFT: Compute the inverse discrete Fourier transform.

k) CSD: If the TXVECTOR parameter BEAM_CHANGE is 1, apply CSD for each transmit chain and frequency segment as described in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

l) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{Pre-HE}}$) and apply windowing as described in 28.3.9 (Mathematical description of signals).

m) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.

28.3.6.5 Construction of RL-SIG

Construct the RL-SIG field as the repeat SIGNAL field defined in 28.3.10.6 (RL-SIG) with the following highlights:

a) Set the RATE subfield in the repeat SIGNAL field to 6 Mb/s. Set the Length Parity, and Tail bits in the repeat SIGNAL field as described in 28.3.10.6 (RL-SIG).

b) BCC encoder: Encode the repeat SIGNAL field by a convolutional encoder at the rate of R = ½ as described in 28.3.11.5.1 (Binary convolutional coding and puncturing).

c) BCC interleaver: Interleave as described in 17.3.5.7 (BCC interleavers).

d) Constellation Mapper: BPSK modulate as described in 28.3.11.9 (Constellation mapping).

e) Pilot insertion: Insert pilots as described in 28.3.10.6 (RL-SIG).

f) Extra tone insertion: Four extra tones are inserted in subcarriers $k \in \{-28, -27, 27, 28\}$ for channel estimation purpose and the values on these four extra tones are $\{-1, -1, -1, 1\}$, respectively. Apply a 3 dB power boost to the four extra tones if transmitting an HE ER SU PPDU as described in 28.3.10.6 (RL-SIG).

g) Duplication and phase rotation: Duplicate the RL-SIG field over each 20 MHz subchannel of the channel bandwidth. Apply appropriate phase rotation for each 20 MHz subchannel as described in 28.3.9 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

h) CSD: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD for each space-time stream and frequency segment as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields) before spatial mapping.

i) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the A matrix and the Q matrix as described in 28.3.10.6 (RL-SIG).

j) IDFT: Compute the inverse discrete Fourier transform.

k) CSD: If the TXVECTOR parameter BEAM_CHANGE is 1, apply CSD for each transmit chain and frequency segment as described in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

l) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{Pre-HE}}$) and apply windowing as described in 28.3.9 (Mathematical description of signals).

m) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.

28.3.6.6 Construction of HE-SIG-A

For an HE SU PPDU, HE MU PPDU, and HE TB PPDU, the HE-SIG-A field consists of two parts, HE-SIG-A1 and HE-SIG-A2 as defined in 28.3.10.7 (HE-SIG-A) and is constructed as follows:

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a) Obtain the HE-SIG-A field values from the TXVECTOR. Add the reserved bits, append the calculated CRC, and then append the N_{tail} tail bits as shown in 28.3.10.7 (HE-SIG-A). This results in 52 uncoded bits.

b) BCC encoder: Encode the data by a convolution encoder at the rate of R = ½ as described in 17.3.5.6 (Convolution encoder).

c) BCC interleaver: Interleave as described in 28.3.11.8 (BCC interleavers).

d) Constellation mapper: BPSK modulate the first 52 interleaved bits as described in 17.3.5.8 (Subcarrier modulation mapping) to form the first symbol of HE-SIG-A. BPSK modulate the second 52 interleaved bits to form the second symbol of HE-SIG-A.

e) Pilot insertion: Insert pilots as described in 17.3.5.9 (Pilot subcarriers).

f) Duplicate and phase rotation: Duplicate the HE-SIG-A OFDM symbols over each 20 MHz subchannel of the channel width. Apply the appropriate phase rotation for each 20 MHz subchannel as described in 28.3.9 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

g) CSD: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD for each space-time stream and frequency segment as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields) before spatial mapping.

h) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the A matrix and the Q matrix as described in 28.3.10.7.4 (Encoding and modulation).

i) IDFT: Compute the inverse discrete Fourier transform.

j) CSD: If the TXVECTOR parameter BEAM_CHANGE is 1, apply CSD for each transmit chain and frequency segment as described in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

k) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{Pre-HE}}$) and apply windowing as described in 28.3.9 (Mathematical description of signals).

l) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.

For an HE ER SU PPDU, the HE-SIG-A field consists of four parts, HE-SIG-A1, HE-SIG-A2, HE-SIG-A3, and HE-SIG-A4. HE-SIG-A1 and HE-SIG-A2 have the same data bits while HE-SIG-A3 and HE-SIG-A4 have the same data bits as defined in 28.3.10.7 (HE-SIG-A). The HE-SIG-A field is constructed as follows:

a) Obtain the HE-SIG-A fields from the TXVECTOR. Add the reserved bits, append the calculated CRC, and then append the N_{tail} tail bits as shown in 28.3.10.7 (HE-SIG-A). This results in 52 uncoded bits.

b) BCC encoder: Encode the data by a convolution encoder at the rate of R = ½ as described in 17.3.5.6 (Convolution encoder).

c) BCC interleaver: Interleave the data bits of HE-SIG-A1 and HE-SIG-A3 as described in 28.3.11.8 (BCC interleavers). The data bits of HE-SIG-A2 and HE-SIG-A4 are not interleaved.

d) Constellation mapper: BPSK modulate the HE-SIG-A1, HE-SIG-A3, and HE-SIG-A4 data bits as described in 17.3.5.8 (Subcarrier modulation mapping) to form the first, third, and fourth symbol of HE-SIG-A, respectively. QBPSK modulate the HE-SIG-A2 encoded data bits to form the second symbol of HE-SIG-A.

e) Pilot insertion: Insert pilots as described in 17.3.5.9 (Pilot subcarriers).

f) CSD: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD for each space-time stream and frequency segment as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields) before spatial mapping.

g) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the A matrix and the Q matrix as described in 28.3.10.7.4 (Encoding and modulation).

h) IDFT: Compute the inverse Fourier transform.

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i) CSD: If the TXVECTOR parameter BEAM_CHANGE is 1, apply CSD for each transmit chain and frequency segment as described in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

j) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{Pre-HE}}$) and apply windowing as described in 28.3.9 (Mathematical description of signals).

k) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.

28.3.6.7 Construction of HE-SIG-B

For an HE MU PPDU, the HE-SIG-B field consists of a Common field followed by a User Specific field as defined in 28.3.10.8 (HE-SIG-B) and is constructed as follows:

a) Obtain for the HE-SIG-B field values from the TXVECTOR. Add the reserved bits, append the calculated CRC, and then append the N_{tail} tail bits as shown in 28.3.10.8 (HE-SIG-B).

b) BCC encoder: Encode the Common field data and each User Block field data individually by a convolution encoder as described in 28.3.11.5.1 (Binary convolutional coding and puncturing).

c) BCC interleaver: Interleave as described in 28.3.11.8 (BCC interleavers).

d) Constellation mapper: Obtain MCS_SIG_B from the TXVECTOR and use it to modulate the interleaved bits as described in 17.3.5.8 (Subcarrier modulation mapping) to form the HE-SIG-B symbols.

e) Pilot insertion: Insert pilots as described in 17.3.5.9 (Pilot subcarriers).

f) Duplicate and phase rotation: Duplicate HE-SIG-B symbols as described in 28.3.10.8.2 (Encoding and modulation). Apply the appropriate phase rotation for each 20 MHz subchannel as described in 28.3.9 (Mathematical description of signals) and 21.3.7.5 (Definition of tone rotation).

g) CSD: If the TXVECTOR parameter BEAM_CHANGE is 0, apply CSD for each space-time stream and frequency segment as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields) before spatial mapping.

h) Spatial mapping: If the TXVECTOR parameter BEAM_CHANGE is 0, apply the A matrix and the Q matrix as described in 28.3.10.7.4 (Encoding and modulation).

i) IDFT: Compute the inverse Fourier transform.

j) CSD: If the TXVECTOR parameter BEAM_CHANGE is 1, apply CSD for each transmit chain and frequency segment as described in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

k) Insert GI and apply windowing: Prepend a GI ($T_{GI,\text{Pre-HE}}$) and apply windowing as described in 28.3.9 (Mathematical description of signals).

l) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.

28.3.6.8 Construction of HE-STF

The HE-STF field is defined in 28.3.10.9 (HE-STF) and is constructed as follows:

a) Sequence generation: Generate the HE-STF in the frequency domain over the bandwidth indicated by the TXVECTOR parameter CH_BANDWIDTH as described in 28.3.10.9 (HE-STF). Apply a 3 dB power boost if transmitting an HE ER SU PPDU as described in 28.3.10.9 (HE-STF).

b) CSD: Apply CSD for each space-time stream and frequency segment as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields).

c) Spatial mapping: Apply the Q matrix as described in 28.3.10.9 (HE-STF).

d) IDFT: Compute the inverse discrete Fourier transform.

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e) Insert GI and apply windowing: Prepend a GI; $T_{GI1,\text{Data}}$ for HE SU PPDU, HE ER SU PPDU, and HE MU PPDU and $T_{GI2,\text{Data}}$ for an HE TB PPDU. Apply windowing as described in 28.3.9 (Mathematical description of signals).

f) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.

28.3.6.9 Construction of HE-LTF

The HE-LTF field is defined in 28.3.10.10 (HE-LTF) and is constructed as follows:

a) Sequence generation: Generate the HE-LTF sequence in frequency domain over the bandwidth indicated by CH_BANDWIDTH as described in 28.3.10.10 (HE-LTF). Apply a 3 dB power boost if transmitting an HE ER SU PPDU as described in 28.3.10.10 (HE-LTF).

b) $A_{\text{HE-LTF}}$ matrix mapping: Apply the $P_{\text{HE-LTF}}$ matrix to the data tones of the HE-LTF sequence and apply the $R_{\text{HE-LTF}}$ matrix to pilot subcarriers except the UL MU-MIMO transmission not using HE single stream pilot HE LTF mode as described in 28.3.10.10 (HE-LTF).

c) CSD: Apply CSD for each space-time stream and frequency segment as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields).

d) Spatial mapping: Apply the Q matrix as described in 28.3.10.10 (HE-LTF).

e) IDFT: Compute the inverse discrete Fourier transform.

f) Insert GI and apply windowing: Prepend a GI indicated by the TXVECTOR parameter GI_TYPE and apply windowing as described in 28.3.9 (Mathematical description of signals).

g) Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.

28.3.6.10 Construction of the Data field in an HE SU PPDU, HE ER SU PPDU, and HE TB PPDU

28.3.6.10.1 Using BCC

The construction of the Data field in an HE SU PPDU, HE ER SU PPDU, and HE TB PPDU with BCC encoding proceeds as follows:

a) Construct the SERVICE field as described in 28.3.11.3 (SERVICE field) and append the PSDU to the SERVICE field.

b) Pre-FEC padding: Append the pre-FEC pad bits and tail bits as described in 28.3.11 (Data field).

c) Scrambler: Scramble the pre-FEC padded data.

d) BCC encoder: BCC encode as described in 28.3.11.5.1 (Binary convolutional coding and puncturing).

e) Post-FEC padding: Append the post-FEC pad bits and packet extension field as described in 28.3.11 (Data field).

f) Stream parser: Rearrange the output of BCC encoder into blocks as described in 28.3.11.6 (Stream parser).

g) Segment parser (if needed): This block is bypassed for 20 MHz transmissions.

h) BCC interleaver: Interleave as described in 28.3.11.8 (BCC interleavers).

i) Constellation mapper: Map to BPSK, QPSK, 16-QAM, 64-QAM, or 256-QAM constellation points as described in 28.3.11.9 (Constellation mapping).

j) Segment deparser (if needed): This block is bypassed for 20 MHz transmissions.

k) STBC: Apply STBC as described in 28.3.11.10 (Space-time block coding).

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l) Pilot insertion: Insert pilots following the steps described in 28.3.11.13 (Pilot subcarriers).

m) CSD: Apply CSD for each space-time stream and frequency segment as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields).

n) Spatial mapping: Apply the *Q* matrix as described in 28.3.11.14 (OFDM modulation).

o) IDFT: In an 80+80 MHz transmission, map each frequency subblock to a separate IDFT. Compute the inverse discrete Fourier transform.

p) Insert GI and apply windowing: Prepend a GI determined by the TXVECTOR parameter GI_TYPE and apply windowing as described in 28.3.9 (Mathematical description of signals).

q) Analog and RF: Upconvert the resulting complex baseband waveform with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.

28.3.6.10.2 Using LDPC

The construction of the Data field in an HE SU PPDU, HE ER SU PPDU, and HE TB PPDU with LDPC encoding proceeds as follows:

a) Construct the SERVICE field as described in 28.3.11.3 (SERVICE field) and append the PSDU to the SERVICE field.

b) Pre-FEC padding: Append the pre-FEC padding bits as described in 28.3.11 (Data field). There are no tail bits.

c) Scrambler: Scramble the pre-FEC padded data.

d) LDPC encoder: LDPC encode as described in 28.3.11.5.2 (LDPC coding).

e) Post-FEC padding: Append the post-FEC pad bits and packet extension field as described in 28.3.11 (Data field).

f) Stream parser: Rearrange the output of LDPC encoder into blocks as described in 28.3.11.6 (Stream parser).

g) Segment parser (if needed): In a 160 MHz or 80+80 MHz transmission with a 2×996-tone RU, divide the output of each stream parser into two frequency subblocks as described in 28.3.11.6 (Stream parser). This block is bypassed for 20 MHz, 40 MHz, and 80 MHz transmissions.

h) Constellation mapper: Map to BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM, or 1024-QAM constellation points as described in 28.3.11.9 (Constellation mapping).

i) LDPC tone mapper: the LDPC tone mapping shall be performed on all LDPC encoded streams as described in 28.3.11.11 (LDPC tone mapper).

j) Segment deparser (if needed): In 160 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 28.3.11.12 (Segment deparser). This block is bypassed for 20 MHz, 40 MHz, 80 MHz, and 80+80 MHz transmissions.

k) STBC: Apply STBC as described in 28.3.11.10 (Space-time block coding).

l) Pilot insertion: Insert pilots following the steps described in 28.3.11.13 (Pilot subcarriers).

m) CSD: Apply CSD for each space-time stream and frequency segment as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields).

n) Spatial mapping: Apply the *Q* matrix as described in 28.3.11.14 (OFDM modulation).

o) IDFT: In an 80+80 MHz transmission, map each frequency subblock to a separate IDFT. Compute the inverse discrete Fourier transform.

p) Insert GI and apply windowing: Prepend a GI determined by the TXVECTOR parameter GI_TYPE and apply windowing as described in 28.3.9 (Mathematical description of signals).

q) Analog and RF: Upconvert the resulting complex baseband waveform with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.

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28.3.6.11 Construction of the Data field in an HE MU PPDU

28.3.6.11.1 General

In an HE MU transmission, the PPDU encoding process is performed independently in an RU on a per user basis up to the input of the spatial mapping block, except that CSD is performed with knowledge of the space-time streams starting index for that user. All user data in an RU is combined and mapped to the transmit chains in the spatial mapping block.

28.3.6.11.2 Using BCC

A Data field with BCC encoding is constructed using steps (a) to (l) in 28.3.6.10.1 (Using BCC), then applying CSD for an HE MU PPDU as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields).

28.3.6.11.3 Using LDPC

A Data field with LDPC encoding is constructed using steps (a) to (l) in 28.3.6.10.2 (Using LDPC), then applying CSD for an HE MU PPDU as described in 28.3.10.2.2 (Cyclic shift for HE modulated fields).

28.3.6.11.4 Combining to form an HE MU PPDU

The per-user data is combined as follows:

a) Spatial mapping: The Q matrix is applied as described in 28.3.11.14 (OFDM modulation). The combining of all user data of an RU is done in this block.

b) IDFT: Compute the inverse discrete Fourier transform.

c) Insert GI and apply windowing: Prepend a GI determined by the TXVECTOR parameter GI_TYPE and apply windowing as described in 28.3.9 (Mathematical description of signals).

d) Analog and RF: Upconvert the resulting complex baseband waveform with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.

28.3.7 HE modulation and coding schemes (HE-MCSs)

The HE-MCS is a compact representation of the modulation and coding used in the Data field of the PPDU. For an HE SU PPDU and an HE ER SU PPDU it is carried in the HE-SIG-A field. For an HE MU PPDU it is carried per user in the User Specific field of the HE-SIG-B field. For an HE TB PPDU, it is carried in the User Info field of the Trigger frame soliciting the HE TB PPDU.

The HE-SIG-B-MCS is a compact representation of the modulation and coding used in the HE-SIG-B field of the PPDU. For an HE MU PPDU, it is carried in the HE-SIG-A field. HE-SIG-B-MCS consists of indices 0 to 5 and each HE-SIG-B-MCS represents the same modulation and coding as the HE-MCS with the same index.

Rate dependent parameters for the full set of HE-MCSs are shown in Table 28-51 (HE-MCSs for 26-tone RU, NSS = 1) to Table 28-106 (HE-MCSs for non-OFDMA 160 MHz and 80+80 MHz, NSS = 8) (in 28.5 (Parameters for HE-MCSs)). These tables give rate-dependent parameters for HE-MCSs with indices 0 to 11, with number of spatial streams from 1 to 8, RU options of 26-tone, 52-tone, 106-tone, 242-tone, 484-tone and 996-tone, and bandwidth options of 20 MHz, 40 MHz, 80 MHz, and either 160 MHz or 80+80 MHz.

HE-MCSs with indices 10 and 11 (1024-QAM) are optionally applied to the Data field of an HE PPDU with RUs equal to or larger than 242-tone.

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The HE ER SU PPDU only supports a single 242-tone or 106-tone RU. The 242-tone RU can only be transmitted with the <HE-MCS, NSS> tuples <MCS 0, 1>, <MCS 1, 1> and <MCS 2, 1>. The 106-tone RU can only be transmitted with the <HE-MCS, NSS> tuple <MCS 0, 1>. The 106-tone RU location within the 20 MHz tone plan is fixed as the one that is higher in frequency.

DCM is an optional modulation scheme used for the HE-SIG-B field and the Data field in an HE PPDU. The use of DCM for the HE-SIG-B field in an HE MU PPDU is indicated in the HE-SIG-A field. The use of DCM on the Data field of an HE SU PPDU and HE ER SU PPDU is indicated in the HE-SIG-A field. The use of DCM in the Data field of an HE MU PPDU is indicated in the HE-SIG-B field. DCM is only applied for the HE-MCSs and HE-SIG-B-MCSs with indices 0, 1, 3 and 4.

28.3.8 Timing-related parameters

Refer to Table 19-6 (Timing-related constants) and Table 21-5 (Timing-related constants) for timing-related parameters for non-HE PPDU formats.

Table 28-12 (Timing-related constants) defines the timing-related parameters for HE PPDU formats.

Table 28-12— Timing-related constants

Parameter	Values	Description
$\Delta_{F,\text{Pre-HE}}$	312.5 kHz	Subcarrier frequency spacing for the pre-HE modulated fields.
$\Delta_{F,\text{HE}}$	78.125 kHz	Subcarrier frequency spacing for the HE modulated fields.
$T_{DFT,\text{Pre-HE}}$	3.2 μs	IDFT/DFT period for the pre-HE modulated fields.
$T_{DFT,\text{HE}}$	12.8 μs	IDFT/DFT period for the HE Data field.
$T_{GI,\text{Pre-HE}}$	0.8 μs	Guard interval duration for the pre-HE preamble.
$T_{GI,\text{L-LTF}}$	1.6 μs	Guard interval duration for the L-LTF field.
$T_{GI1,Data}$	0.8 μs	Base guard interval duration for the HE-Data field.
$T_{GI2,Data}$	1.6 μs	Double guard interval duration for the HE-Data field.
$T_{GI4,Data}$	3.2 μs	Quadruple guard interval duration for the HE-Data field.
$T_{GI,\text{HE-LTF}}$	$T_{GI1,Data}$, $T_{GI2,Data}$ or $T_{GI4,Data}$ depending on the GI used for data	Guard interval duration for the HE-LTF field, same as $T_{GI,Data}$
$T_{GI,Data}$	$T_{GI1,Data}$, $T_{GI2,Data}$ or $T_{GI4,Data}$ depending on the GI used for data	Guard interval duration for the HE-Data field
T_{SYM1}	13.6 μs = $T_{DFT,\text{HE}} + T_{GI1,Data} = 1.0625 \times T_{DFT,HE}$	OFDM symbol duration with base GI
T_{SYM2}	14.4 μs = $T_{DFT,\text{HE}} + T_{GI2,Data} = 1.125 \times T_{DFT,HE}$	OFDM symbol duration with double GI
T_{SYM4}	16 μs = $T_{DFT,\text{HE}} + T_{GI4,Data} = 1.25 \times T_{DFT,\text{HE}}$	OFDM symbol duration with quadruple GI

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Table 28-12— Timing-related constants *(continued)*

T_{SYM}	T_{SYM1}, T_{SYM2}, or T_{SYM4} depending on the GI used	OFDM symbol interval for HE PPDU fields. See Table 28-16 (Number of modulated sub-carriers and guard interval duration values for HE PPDU fields).
$T_{\text{L-STF}}$	8 μs = 10 × $T_{DFT,\text{Pre-HE}}$ /4	Non-HT Short Training field duration
$T_{\text{L-LTF}}$	8 μs = 2 × $T_{DFT,\text{Pre-HE}}$ + $T_{GI,\text{L-LTF}}$	Non-HT Long Training field duration
$T_{\text{L-SIG}}$	4 μs	Non-HT SIGNAL field duration
$T_{\text{RL-SIG}}$	4 μs	Repeated non-HT SIGNAL field duration
$T_{\text{HE-SIG-A}}$	8 μs = 2 × 4 μs	HE-SIG-A field duration in an HE SU PPDU, HE MU PPDU and HE TB PPDU
$T_{\text{HE-SIG-A-R}}$	16 μs = 4 × 4 μs	HE-SIG-A field duration in an HE ER SU PPDU
$T_{\text{HE-STF-T}}$	8 μs = 5 × 1.6 μs	HE-STF field duration for an HE TB PPDU
$T_{\text{HE-STF-NT}}$	4 μs = 5 × 0.8 μs	HE-STF field duration for an HE SU PPDU, HE ER SU PPDU and HE MU PPDU
$T_{\text{HE-LTF-1X}}$	3.2 μs	Duration of each 1x HE-LTF OFDM symbol without GI
$T_{\text{HE-LTF-2X}}$	6.4 μs	Duration of each 2x HE-LTF OFDM symbol without GI
$T_{\text{HE-LTF-4X}}$	12.8 μs	Duration of each 4x HE-LTF OFDM symbol without GI
$T_{\text{HE-LTF}}$	$T_{\text{HE-LTF-1X}}$, $T_{\text{HE-LTF-2X}}$ or $T_{\text{HE-LTF-4X}}$ depending upon the LTF duration used	Duration of each OFDM symbol without GI in the HE-LTF field
$T_{\text{HE-LTF-SYM}}$	$T_{\text{HE-LTF}}$ + $T_{GI,\text{HE-LTF}}$	Duration of each OFDM symbol including GI in the HE-LTF field
$T_{\text{HE-SIG-B}}$	4 μs = $T_{DFT,\text{Pre-HE}}$ + $T_{GI,\text{Pre-HE}}$	Duration of each OFDM symbol in the HE-SIG-B field
$N_{service}$	16	Number of bits in the SERVICE field
N_{tail}, $N_{tail,u}$	6 for BCC encoder, 0 for LDPC encoder	Number of tail bits per encoder (for user u)
T_{SYML}	4 μs	Symbol duration including GI prior to the HE-STF field
T_{PE}	0, 4 μs, 8 μs, 12 μs or 16 μs depending on the actual extension duration used	Duration of the Packet Extension field

Table 28-13 (Tone allocation related constants for the Data field in a non-OFDMA HE PPDU) defines tone allocation related parameters for a non-OFDMA HE PPDU.

Table 28-13—Tone allocation related constants for the Data field in a non-OFDMA HE PPDU

Parameter	CBW20	CBW40	CBW80	CBW80+80	CBW160	Description

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Table 28-13—Tone allocation related constants for the Data field in a non-OFDMA HE PPDU

N_{SD}	234	468	980	980	1960	Number of data subcarriers per frequency segment
N_{SP}	8	16	16	16	32	Number of pilot subcarriers per frequency segment
N_{ST}	242	484	996	996	1992	Total number of subcarriers per frequency segment
N_{SR}	122	244	500	500	1012	Highest data subcarrier index per frequency segment
N_{Seg}	1	1	1	2	1	Number of frequency segments
N_{DC}	3	5	5	5	23	Number of null subcarriers at DC per segment
$N_{Guard,Left}$	6	12	12	12	12	Number of low frequency guard subcarriers
$N_{Guard,Right}$	5	11	11	11	11	Number of high frequency guard subcarriers
NOTE: $N_{ST} = N_{SD} + N_{SP}$						

Table 28-14 (Tone allocation related constants for RUs in an OFDMA HE PPDU) defines tone allocation related parameters for a OFDMA HE PPDU.

Table 28-14—Tone allocation related constants for RUs in an OFDMA HE PPDU

Parameter	RU Size (tones)							Description
	26	**52**	**106**	**242**	**484**	**996**	**2×996**	
N_{SD}	24	48	102	234	468	980	1960	Number of data subcarriers per RU
N_{SP}	2	4	4	8	16	16	32	Number of pilot subcarriers per RU
N_{ST}	26	52	106	242	484	996	1992	Total number of subcarriers per RU
NOTE: $N_{ST} = N_{SD} + N_{SP}$								

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Table 28-15 (Frequently used parameters) defines parameters used frequently in Clause 28 (High Efficiency (HE) PHY specification).

Table 28-15—Frequently used parameters

Symbol	Explanation
N_{CBPS}, $N_{CBPS,u}$	Number of coded bits per symbol for user u, $u = 0, ..., N_{user,total} - 1$, where $N_{user,total}$ is the total number of users in all occupied RUs of an HE transmission For an HE SU PPDU, $N_{CBPS} = N_{CBPS,0}$ For an HE MU PPDU, N_{CBPS} is undefined
N_{CBPSS}, $N_{CBPSS,u}$	Number of coded bits per symbol per spatial stream. For the Data field, $N_{CBPSS,u}$ equals the number of coded bits per symbol per spatial stream for user u, $u = 0, ..., N_{user,total} - 1$. For the Data field of an HE SU PPDU, $N_{CBPSS} = N_{CBPSS,0}$ For the Data field of an HE MU PPDU, N_{CBPSS} is undefined
N_{DBPS}, $N_{DBPS,u}$	Number of data bits per symbol for user u, $u = 0, ..., N_{user,total} - 1$. For an HE SU PPDU, $N_{DBPS} = N_{DBPS,0}$ For an HE MU PPDU, N_{DBPS} is undefined
N_{BPSCS}, $N_{BPSCS,u}$	Number of coded bits per subcarrier per spatial stream for user u, $u = 0, ..., N_{user,total} - 1$. For an HE SU PPDU, $N_{BPSCS} = N_{BPSCS,0}$ For an HE MU PPDU, N_{BPSCS} is undefined
N_{RX}	Number of receive chains
N_{RU}	For pre-HE modulated fields, $N_{RU} = 1$. For HE modulated fields, N_{RU} represents the number of occupied RUs in the transmission.
$N_{user,r}$	For pre-HE modulated fields, $N_{user,r} = 1$. For HE modulated fields, $N_{user,r}$ represents the total number of users in the r-th RU of the transmission.
N_{STS}, $N_{STS,r,u}$	For pre-HE modulated fields, $N_{STS,r,u} = 1$ (see NOTE). For HE modulated fields, $N_{STS,r,u}$ represents the number of space-time streams in the r-th RU for user u, $u = 0, ..., N_{user,r} - 1$. For STBC, $N_{STS,r,u} = 2$. For an HE SU PPDU, $N_{STS} = N_{STS,0,0}$ For an HE MU PPDU, $N_{STS} = max_{r=0}^{N_{RU}-1} N_{STS,r,total}$

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Table 28-15—Frequently used parameters *(continued)*

$N_{STS,r,total}$	For HE modulated fields, $N_{STS,r,total}$ is the total number of space-time streams over all the users in the r-th RU. $N_{STS,r,total} = \sum_{u=0}^{N_{user,r}-1} N_{STS,r,u}$ For pre-HE modulated fields, $N_{STS,r,total}$ is undefined when the TXVECTOR parameter BEAM_CHANGE is 1 and $N_{STS,r,total} = N_{STS}$ when BEAM_CHANGE is 0. Note that $N_{STS,r,total} = N_{STS}$ for an HE SU PPDU.
N_{SS}, $N_{SS,r,u}$, $N_{SS,u}$	Number of spatial streams. For the Data field, $N_{SS,r,u}$ is the number of spatial streams at r-th RU for user u, $u = 0, ..., N_{user,r} - 1$ and $N_{SS,u}$ is the number of spatial streams for user u, $u = 0, ..., N_{user,total} - 1$. For the Data field of an HE SU PPDU, $N_{SS} = N_{SS,0,0}$ For the Data field of an HE MU PPDU, $N_{SS} = max_{r=0}^{N_{RU}-1} N_{SS,r,total}$
$N_{SS,r,total}$	For HE modulated fields, $N_{SS,r,total}$ is the total number of spatial streams at r-th RU in a PPDU. $N_{SS,r,total} = \sum_{u=0}^{N_{user,r}-1} N_{SS,r,u}$ For pre-HE modulated fields, $N_{SS,r,total}$ is undefined. Note that $N_{SS,r,total} = N_{SS}$ for an HE SU PPDU.
N_{TX}	Number of transmit chains
$N_{HE\text{-}LTF}$	The number of OFDM symbols in the HE-LTF field (see 28.3.10.10 (HE-LTF))
$N_{HE\text{-}SIG\text{-}B}$	The number of OFDM symbols in the HE-SIG-B field (see 28.3.10.8 (HE-SIG-B))
K_r	Set of used subcarrier indices in the r-th RU
R, R_u	R_u is the coding rate for user u, $u = 0, ..., N_{user,total} - 1$. For an HE SU PPDU, $R = R_0$ For an HE MU PPDU, R is undefined
$M_{r,u}$	The sum of the number of space-time streams of users prior to user u in RU r. For pre-HE modulated fields, $M_{r,u} = 0$. For HE modulated fields, $M_{r,0} = 0$ for $u = 0$ and $M_{r,u} = \sum_{u'=0}^{u-1} N_{STS,r,u'}$ for $u = 1, ..., N_{user,r} - 1$.
NOTE—For pre-HE modulated fields, u and r are zeros only since $N_{user,r} = 1$ and $N_{RU} = 1$.	

28.3.9 Mathematical description of signals

For a description of the conventions used for the mathematical description of the signals, see 17.3.2.5 (Mathematical conventions in the signal descriptions). In addition, the following notational conventions are used in Clause 28 (High Efficiency (HE) PHY specification):

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$[Q]_{m,n}$ indicates the element in row m and column n of matrix, where $1 \le m \le N_{row}$ and $1 \le n \le N_{col}$

N_{row} and N_{col} are the number of rows and columns, respectively, of the matrix Q.

$[Q]_{m:n}$ indicates a matrix consisting of columns m to n of matrix Q.

For a description on subcarrier indices over which the signal is transmitted for non-HT, HT and VHT PPDUs, see 21.3.7 (Mathematical description of signals).

For a 20 MHz non-OFDMA HE PPDU transmission, the 20 MHz is divided into 256 subcarriers. The signal is transmitted on all or a subset of subcarriers –122 to –2 and 2 to 122, with 0 being the center (DC) subcarrier.

For a 20 MHz OFDMA HE PPDU transmission, the 20 MHz is divided into 256 subcarriers. The signal is transmitted on all or a subset of the subcarriers –122 to –4 and 4 to 122, with 0 being the center (DC) subcarrier.

For a 40 MHz non-OFDMA HE PPDU transmission, the 40 MHz is divided into 512 subcarriers. The signal is transmitted on subcarriers –244 to –3 and 3 to 244, with 0 being the center (DC) subcarrier.

For a 40 MHz OFDMA HE PPDU transmission, the 40 MHz is divided into 512 subcarriers. The signal is transmitted on all or a subset of subcarriers –244 to –3 and 3 to 244, with 0 being the center (DC) subcarrier.

For an 80 MHz non-OFDMA HE PPDU transmission, the 80 MHz is divided into 1024 subcarriers. The signal is transmitted on subcarriers –500 to –3 and 3 to 500, with 0 being the center (DC) subcarrier.

For an 80 MHz OFDMA HE PPDU transmission, the 80 MHz is divided into 1024 subcarriers. The signal is transmitted on all or a subset of the subcarriers –500 to –4 and 4 to 500, with 0 being the center (DC) subcarrier.

For a 160 MHz HE PPDU transmission or a noncontiguous 80+80 MHz transmission, and each half 80 MHz bandwidth is divided into 1024 subcarriers, and the subcarriers on which the signal is transmitted in each 80 MHz bandwidth is identical to an 80 MHz HE PPDU transmission, depending on non-OFDMA or OFDMA transmission within the corresponding 80 MHz.

The transmitted signal is described in complex baseband signal notation. The actual transmitted signal on transmit chain i_{TX} and frequency segment i_{Seg} is related to the complex baseband signal by the relation shown in Equation (28-1).

$$r_{RF}^{(i_{Seg}, i_{TX})}(t) = \mathrm{Re}\left\{ \frac{1}{\sqrt{N_{Seg}}} r_{PPDU}^{(i_{Seg}, i_{TX})}(t) \exp\left(j2\pi f_c^{(i_{Seg})} t\right) \right\}, \quad i_{Seg} = 0, \ldots, N_{Seg} - 1; \; i_{TX} = 1, \ldots, N_{TX} \quad (28\text{-}1)$$

where

N_{Seg} represents the number of frequency segments in the transmit signal as defined in Table 28-13 (Tone allocation related constants for the Data field in a non-OFDMA HE PPDU)

$r_{PPDU}^{(i_{Seg}, i_{TX})}$ represents the complex baseband signal of frequency segment i_{Seg} and transmit chain i_{TX}

$f_c^{(i_{Seg})}$ represents the center frequency of frequency segment i_{Seg}

The transmitted RF signal is derived by up-converting the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure 28-22 (Timing boundaries for HE PPDU fields), where $N_{\text{HE-LTF}}$ is the number of HE-LTF symbols and is defined in Table 28-15 (Fre-

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quently used parameters), $N_{\text{HE-SIG-B}}$ is the number of symbols in the HE-SIG-B field present in an HE MU PPDU, and N_{SYM} is the number of symbols in the Data field.

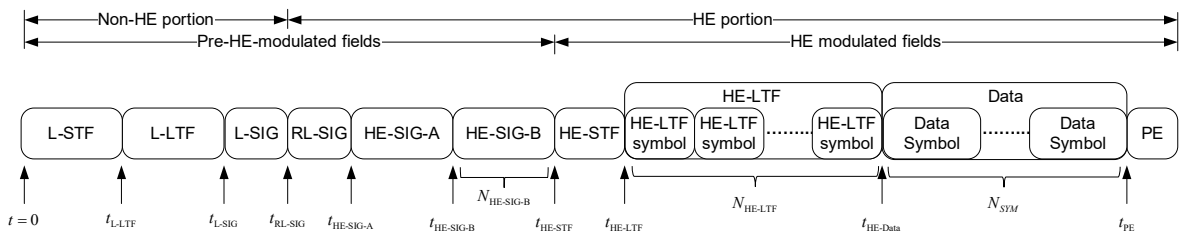


Figure 28-22—Timing boundaries for HE PPDU fields

The time offset, t_{Field}, determines the starting time of the corresponding field relative to the start of L-STF ($t = 0$).

The signal transmitted on frequency segment i_{Seg} and transmit chain i_{TX} shall be as shown in Equation (28-2).

$$\begin{aligned} r_{PPDU}^{(i_{Seg}, i_{TX})}(t) = {} & r_{\text{L-STF}}^{(i_{Seg}, i_{TX})}(t) + r_{\text{L-LTF}}^{(i_{Seg}, i_{TX})}(t - t_{\text{L-LTF}}) \\ & + r_{\text{L-SIG}}^{(i_{Seg}, i_{TX})}(t - t_{\text{L-SIG}}) + r_{\text{RL-SIG}}^{(i_{Seg}, i_{TX})}(t - t_{\text{RL-SIG}}) + r_{\text{HE-SIG-A}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-SIG-A}}) + r_{\text{HE-SIG-B}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-SIG-B}}) \\ & + r_{\text{HE-STF}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-STF}}) + r_{\text{HE-LTF}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-LTF}}) + r_{\text{HE-Data}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-Data}}) + r_{\text{HE-PE}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-PE}}) \end{aligned} \quad (28\text{-}2)$$

where

$r_{\text{HE-SIG-B}}^{(i_{Seg}, i_{TX})}(t - t_{\text{HE-SIG-B}})$ is only applicable to an HE MU PPDU

$0 \le i_{Seg} \le N_{Seg} - 1$

$1 \le i_{TX} \le N_{TX}$

$t_{\text{L-LTF}} = T_{\text{L-STF}}$

$t_{\text{L-SIG}} = t_{\text{L-LTF}} + T_{\text{L-LTF}}$

$t_{\text{RL-SIG}} = t_{\text{L-SIG}} + T_{\text{L-SIG}}$

$t_{\text{HE-SIG-A}} = t_{\text{RL-SIG}} + T_{\text{RL-SIG}}$

$$t_{\text{HE-SIG-B}} = \begin{cases} t_{\text{HE-SIG-A}} + T_{\text{HE-SIG-A}}, & \text{for an HE MU PPDU} \\ undefined, & \text{otherwise} \end{cases}$$

$$t_{\text{HE-STF}} = \begin{cases} t_{\text{HE-SIG-A}} + T_{\text{HE-SIG-A}}, & \text{for an HE SU PPDU and HE TB PPDU} \\ t_{\text{HE-SIG-A}} + T_{\text{HE-SIG-A-R}}, & \text{for an HE ER SU PPDU} \\ t_{\text{HE-SIG-B}} + N_{\text{HE-SIG-B}} T_{\text{HE-SIG-B}}, & \text{for an HE MU PPDU} \end{cases}$$

$$t_{\text{HE-LTF}} = \begin{cases} t_{\text{HE-STF}} + T_{\text{HE-STF-T}}, & \text{for an HE TB PPDU} \\ t_{\text{HE-STF}} + T_{\text{HE-STF-NT}}, & \text{otherwise} \end{cases}$$

$$t_{\text{HE-Data}} = \begin{cases} t_{\text{HE-LTF}} + N_{\text{HE-LTF}} \cdot (T_{\text{HE-LTF-1X}} + T_{\text{GI,HE-LTF}}), & \text{for 1x HE-LTF} \\ t_{\text{HE-LTF}} + N_{\text{HE-LTF}} \cdot (T_{\text{HE-LTF-2X}} + T_{\text{GI,HE-LTF}}), & \text{for 2x HE-LTF} \\ t_{\text{HE-LTF}} + N_{\text{HE-LTF}} \cdot (T_{\text{HE-LTF-4X}} + T_{\text{GI,HE-LTF}}), & \text{for 4x HE-LTF} \end{cases}$$

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$$t_{\text{HE-PE}} = t_{\text{HE-Data}} + N_{SYM} T_{SYM}$$

In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, for each field excluding the PE field, $r_{Field_i}^{(i_{Seg}, i_{TX})}(t)$ is defined in Equation (28-3) as the summation of one or more subfields. Each subfield, $r_{Subfield}^{(i_{Seg}, i_{TX})}(t)$, is defined to be an inverse discrete Fourier transform.

$$r_{Subfield}^{(i_{Seg}, i_{TX})}(t) = w_{T_{Subfield}}(t) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r \beta_r^{Field}}{\sqrt{N_{Norm}}} \sum_{k \in K_r} \eta_{Field,k} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left[Q_k^{(i_{Seg})} \right]_{i_{TX}, (M_{r,u}+m)} \Upsilon_{k,BW} \quad (28\text{-}3)$$

$$X_{k,r,u}^{i_{Seg}, m} \exp(j2\pi k \Delta_{F,Field}(t - T_{GI,Field} - T_{CS,\text{HE}}(M_{r,u} + m)))$$

In an HE TB PPDU, transmitted by user u in the r-th RU, each subfield, $r_{Subfield}^{(i_{Seg}, i_{TX})}(t)$, is defined in Equation (28-4).

$$r_{Subfield,r,u}^{(i_{Seg}, i_{TX})}(t) = \frac{\beta_r^{Field}}{\sqrt{N_{Norm,r}}} w_{T_{Subfield}}(t) \sum_{k \in K_r} \eta_{Field,k} \sum_{m=1}^{N_{STS,r,u}} \left[Q_{k,u}^{(i_{Seg})} \right]_{i_{TX}, m} \Upsilon_{k,BW} \quad (28\text{-}4)$$

$$X_{k,r,u}^{(i_{Seg}, m)} \exp(j2\pi k \Delta_{F,Field}(t - T_{GI,Field} - T_{CS,\text{HE}}(M_{r,u} + m)))$$

In the remainder of this subclause, pre-HE modulated fields refer to the L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A, and HE-SIG-B fields, while HE modulated fields refer to the HE-STF, HE-LTF, Data, and PE fields, as shown in Figure 28-22 (Timing boundaries for HE PPDU fields). The total power of the time domain HE modulated field signals summed over all transmit chains should not exceed the total power of the time domain pre-HE modulated field signals summed over all transmit chains when the TXVECTOR parameter BEAM_CHANGE is 1 and power boost in HE modulated fields is not present. For notational simplicity, the parameter BW is omitted from some bandwidth dependent terms.

In Equation (28-3) and Equation (28-4) the following notations are used:

$N_{Norm,r}$ If the TXVECTOR parameter BEAM_CHANGE is 1, then for pre-HE modulated fields, $N_{Norm,r} = N_{TX}$. If the TXVECTOR parameter BEAM_CHANGE is 0, then for pre-HE modulated fields $N_{Norm,r} = N_{STS,r,total}$, where $N_{STS,r,total}$ is given in Table 28-15 (Frequently used parameters). For HE modulated fields $N_{Norm,r} = N_{STS,r,total}$.

$w_{Subfield}(t)$ is a windowing function. An example function, $w_{Subfield}(t)$, is given in 17.3.2.5 (Mathematical conventions in the signal descriptions).

K_r For pre-HE modulated fields, K_r is the set of subcarriers indices in the allocated 20 MHz channels. For HE modulated fields in a non-OFDMA HE PPDU, K_r is the set of subcarriers indices from $-N_{SR}$ to N_{SR} as defined in Table 28-13 (Tone allocation related constants for the Data field in a non-OFDMA HE PPDU) excluding DC subcarriers. For HE modulated fields in an OFDMA HE PPDU, K_r is the set of subcarrier indices for the tones in the r-th RU as defined in Table 28-6 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU), Table 28-7 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU) excluding DC subcarriers.

$\eta_{Field,k}$ is the power boost factor of the k-th subcarrier of a given field within an OFDM symbol, which is $\sqrt{2}$ for all the subcarriers of the L-STF, L-LTF, HE-STF and HE-LTF fields in the HE ER SU PPDU. For the L-SIG and RL-SIG fields of an HE ER SU PPDU,

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$$\eta_{Field,k} = \begin{cases} \sqrt{2}, k = -28, -27, 27, 28 \\ 1, \text{ otherwise} \end{cases}$$

For the HE-SIG-A and Data fields in an HE ER SU PPDU, and all fields in other HE PPDUs, $\eta_{Field,k} = 1$.

α_r is the power boost factor for the *r*-th RU in an HE PPDU. For a DL HE MU PPDU, an AP shall limit the ratio between the maximum value of α_r and the minimum value of α_r to 2 unless the Power Boost Factor subfield of the HE PHY Capabilities Information field in the HE Capabilities element from all recipient STAs is 1, in which case the AP can use a ratio of up to 4. For an HE SU PPDU, HE ER SU PPDU and HE TB PPDU, α_r is always set to 1.

β_r^{Field} is the power normalization factor and is defined in Equation (28-5)

$$\beta_r^{Field} = \begin{cases} \dfrac{\varepsilon_{Field}}{\sqrt{N_{Field}^{\text{Tone}}}}, \text{ for pre-HE modulated fields} \\ \dfrac{1}{\sqrt{K_r^{Field}}}, \text{ for HE modulated fields in an HE TB PPDU} \\ \sqrt{\dfrac{|K_r|}{|K_r^{Field}|}} \Big/ \sqrt{\sum_{r=0}^{N_{RU}-1} \alpha_r^2 |K_r|}, \text{ otherwise} \end{cases} \quad (28\text{-}5)$$

$|K_r|$ is the cardinality of the set of subcarriers K_r

$|K_r^{Field}|$ is the cardinality of the set of modulated subcarriers within K_r for the HE-STF and Data fields. For the HE-LTF field,

$$|K_r^{\text{HE-LTF}}| = \begin{cases} |K_r|, \text{ for a 4x HE-LTF} \\ |K_r|/2, \text{ for a 2x HE-LTF} \\ |K_r|/4, \text{ for a 1x HE-LTF} \end{cases}$$

N_{Field}^{Tone} Table 28-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields) summarizes the various values of N_{Field}^{Tone} as a function of bandwidth per frequency segment. In the case of an HE OFDMA PPDU, the N_{Field}^{Tone} value of HE-STF, HE-LTF and HE-Data fields is variable, and is determined by which RUs of the current full bandwidth are transmitted in the PPDU.

Table 28-16—Number of modulated subcarriers and guard interval duration values for HE PPDU fields

Field	N_{Field}^{Tone} as a function of bandwidth, and RU size per frequency segment				Guard interval duration
	20 MHz	40 MHz	80 MHz	160 MHz	
L-STF	12	24	48	96	-
L-LTF	52	104	208	416	$T_{GI,\text{L-LTF}}$

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Table 28-16—Number of modulated subcarriers and guard interval duration values for HE PPDU fields *(continued)*

L-SIG in an HE PPDU	56	112	224	448	$T_{GI,\text{Pre-HE}}$
L-SIG in a non-HT duplicate PPDU	-	104	208	416	
RL-SIG	56	112	224	448	$T_{GI,\text{Pre-HE}}$
HE-SIG-A	56	112	224	448	$T_{GI,\text{Pre-HE}}$
HE-SIG-B	56	112	224	448	$T_{GI,\text{Pre-HE}}$
HE-STF not in an HE TB PPDU	14	30	62	124	-
HE-STF in an HE TB PPDU	30	60	124	248	-
HE-LTF 1x Duration	60	122	250	500	$T_{GI,\text{HE-LTF}}$
HE-LTF 2x Duration	122	242	498	996	$T_{GI,\text{HE-LTF}}$
HE-LTF 4x Duration	242	484	996	1992	$T_{GI,\text{HE-LTF}}$
HE-Data	242	484	996	1992	$T_{GI,Data}$
NON_HT_DUP_OFDM-Data	-	104	208	416	$T_{GI,\text{Pre-HE}}$

NOTE—in the case of an HE OFDMA PPDU, the N_{Field}^{Tone} value of HE-STF, HE-LTF and HE-Data fields is variable, and is determined by which RUs of the current full bandwidth are transmitted in the PPDU.

$$\varepsilon_{Field} = \begin{cases} \sqrt{\frac{N_{\text{L-LTF}}^{\text{Tone}}}{N_{\text{L-SIG}}^{\text{Tone}}}}, \text{ For the L-STF and L-LTF fields} \\ 1, \text{ otherwise} \end{cases}$$

$Q_k^{(i_{Seg})}$ is the spatial mapping matrix for the subcarrier k in frequency segment i_{Seg}. For HE modulated fields, $Q_k^{(i_{Seg})}$ is a matrix with N_{TX} rows and $N_{STS,r,total}$ columns. If the TXVECTOR parameter BEAM_CHANGE is 1, then for pre-HE modulated fields $Q_k^{(i_{Seg})}$ is a column vector with N_{TX} elements with element i_{TX} being $\exp(-j2\pi k\Delta_{F,\text{ Pre-HE}}T_{CS}^{i_{TX}})$, where $T_{CS}^{i_{TX}}$ represents the cyclic shift for the transmitter chain whose values are defined in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields); otherwise it is identical to the spatial mapping $Q_k^{(i_{Seg})}$ for HE modulated fields.

$Q_{k,u}^{(i_{Seg})}$ is the spatial mapping matrix for user u on subcarrier k in frequency segment i_{Seg}. For HE modulated fields, $Q_{k,u}^{(i_{Seg})}$ is a matrix with N_{TX} rows and $N_{STS,r,u}$ columns. For pre-HE modulated fields, $Q_{k,u}^{(i_{Seg})}$ is a column vector with N_{TX} elements with element i_{TX} being $\exp(-j2\pi k\Delta_{F,\text{ Pre-HE}}T_{CS}^{i_{TX}})$, where $T_{CS}^{i_{TX}}$ represents the cyclic shift for the transmitter chain whose values are defined in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

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$\Delta_{F, Field}$ is the subcarrier frequency spacing. For pre-HE modulated fields, $\Delta_{F, Field} = \Delta_{F, \text{Pre-HE}}$ given in Table 28-12 (Timing-related constants). For HE modulated fields, $\Delta_{F, Field} = \Delta_{F, \text{HE}}$ given in Table 28-12 (Timing-related constants).

$X_{k, r, u}^{(i_{Seg}, m)}$ is the frequency-domain symbol in subcarrier k of user u in the r-th RU for frequency segment i_{Seg} of space-time stream m. Some of the $X_{k, r, u}^{(i_{Seg}, m)}$ within $-N_{SR} \le k \le N_{SR}$ have a value of zero. Examples of such cases include the DC tones, guard tones on each side of the transmit spectrum, the null subcarriers in an HE OFDMA PPDU, as well as the unmodulated tones of L-STF, HE-STF, and HE-LTF fields.

$T_{GI, Field}$ is the guard interval duration used for each OFDM symbol in the field. The value for each field is defined in Table 28-12 (Timing-related constants).

$T_{CS, \text{HE}}(l)$ For pre-HE modulated fields, $T_{CS, \text{HE}}(l) = 0$. For HE modulated fields, $T_{CS, \text{HE}}(l)$ represents the cyclic shift per space-time stream, whose value is defined in 28.3.10.2.2 (Cyclic shift for HE modulated fields).

$\Upsilon_{k, BW}$ is used to represent tone rotation. BW in $\Upsilon_{k, BW}$ is determined by the TXVECTOR parameter CH_BANDWIDTH as defined in Table 28-17 (CH_BANDWIDTH and for pre-HE modulated fields). In HE modulated fields, $\Upsilon_{k, BW} = 1$ for all the subcarriers. In pre-HE modulated fields, $\Upsilon_{k, BW}$ is defined as in 21.3.7.5 (Definition of tone rotation) when TXVECTOR parameter BEAM_CHANGE is set to 1 and $\Upsilon_{k, BW} = 1$ for all the subcarriers when TXVECTOR parameter BEAM_CHANGE is set to 0. When the TXVECTOR parameter BEAM_CHANGE is not present (such as in an HE MU PPDU and HE TB PPDU), BEAM_CHANGE is assumed to be set to 1.

Table 28-17—CH_BANDWIDTH and $\Upsilon_{k, BW}$ for pre-HE modulated fields

CH_BANDWIDTH	$\Upsilon_{k,\text{BW}}$
CBW20	$\Upsilon_{k, 20}$
CBW40	$\Upsilon_{k, 40}$
CBW80	$\Upsilon_{k, 80}$
CBW160	$\Upsilon_{k, 160}$
CBW80+80	$\Upsilon_{k, 80}$ per frequency segment

28.3.10 HE preamble

28.3.10.1 Introduction

The HE preamble consists of pre-HE modulated fields and HE modulated fields. The pre-HE modulated fields for the various HE PPDU formats are the following:

— L-STF, L-LTF, L-SIG, RL-SIG and HE-SIG-A fields of an HE SU PPDU

— L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A and HE-SIG-B fields of an HE MU PPDU

— L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A (repeated as described in 28.3.6 (Overview of the PPDU encoding process)) fields of an HE ER SU PPDU

— L-STF, L-LTF, L-SIG, RL-SIG and HE-SIG-A fields of an HE TB PPDU

The HE modulated fields in the preamble for all HE PPDU formats are the HE-STF and HE-LTF fields.

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28.3.10.2 Cyclic shift

28.3.10.2.1 Cyclic shift for pre-HE modulated fields

When the TXVECTOR parameter BEAM_CHANGE is 1, the cyclic shift value $T_{CS}^{i_{TX}}$ for the L-STF, L-LTF, L-SIG, RL-SIG and HE-SIG-A fields of the PPDU for transmit chain i_{TX} out of a total of N_{TX} are defined in Table 21-10 (Cyclic shift values for L-STF, L-LTF, L-SIG, and VHT-SIG-A fields of the PPDU). In UL MU transmission the cyclic shift value $T_{CS}^{i_{TX}}$ is based on the local transmit chain indices at each STA.

When the TXVECTOR parameter BEAM_CHANGE is 0, the cyclic shift value $T_{CS}^{i_{TX}}$ for the L-STF, L-LTF, L-SIG, RL-SIG, and HE-SIG-A fields is $T_{CS,\,\mathrm{HE}}(n)$ as specified in 28.3.10.2.2 (Cyclic shift for HE modulated fields).

28.3.10.2.2 Cyclic shift for HE modulated fields

The cyclic shift values defined in this subclause apply to the HE-STF, HE-LTF and Data fields of the HE PPDU when the TXVECTOR parameter BEAM_CHANGE is 1, and apply to the entire PPDU when the TXVECTOR parameter BEAM_CHANGE is 0.

Throughout the HE modulated fields of the preamble, cyclic shifts are applied to prevent unintended beamforming when correlated signals are transmitted in multiple space-time streams. The same cyclic shift is also applied to these streams during the transmission of the Data field of the HE PPDU. For the *r*-th RU, the cyclic shift value $T_{CS,\,\mathrm{HE}}(n)$ for the HE modulated fields for space-time stream *n* out of $N_{STS,r,total}$ total space-time streams is shown in Table 21-11 (Cyclic shift values for the VHT modulated fields of a PPDU).

28.3.10.3 L-STF

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain representation of the L-STF field shall be as specified in Equation (28-6). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-STF}}^{(i_{Seg},\,i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{TX}\cdot N_{\text{L-STF}}^{\text{Tone}}}} w_{T_{\text{L-STF}}}(t) \sum_{i_{BW}\in\Omega_{20\text{MHz}}} \sum_{k=-26}^{26} \eta_{\text{L-STF},\,k} \left(\begin{array}{l} \Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\,\text{BW}} S_{k,\,20} \\ \cdot \exp(j2\pi(k-K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t-T_{CS}^{i_{TX}})) \end{array} \right) \tag{28-6}$$

where

ε is a power scaling factor with the value $\varepsilon = \sqrt{\frac{N_{\text{Tone}}^{\text{L-LTF}}}{N_{\text{Tone}}^{\text{L-SIG}}}}$

$\eta_{\text{L-STF},\,k}$ is a PPDU format dependent scaling factor for the L-STF field on tone index *k* with the following value

$$\eta_{\text{L-STF},\,k} = \begin{cases} \sqrt{2}, & \text{for an HE ER SU PPDU} \\ 1, & \text{otherwise} \end{cases} \tag{28-7}$$

$N_{20\text{MHz}}$ is defined in 21.3.7.3 (Channel frequencies)

$K_{Shift}(i) = (N_{20\text{MHz}} - 1 - 2i)\cdot 32$

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$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} with a value given in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

$N_{\text{L-STF}}^{\text{Tone}}$ has the value given in Table 28-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields).

$\Omega_{20\text{MHz}}$ is a set of 20 MHz channels that contains the channels where pre-HE modulated fields are located. The set of 20 MHz channels contains one or more values in the range 0 to $N_{20\text{MHz}} - 1$ for an HE TB PPDU or HE MU PPDU with preamble puncturing, and it contains all values in the range 0 to $N_{20\text{MHz}} - 1$ for other HE PPDU formats.

$S_{k,20}$ is defined as $S_{-26,26}$ in Equation (19-8).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain representation of the L-STF field of contiguous 20 MHz, 40 MHz, 80 MHz and 160 MHz transmission shall be as specified in Equation (28-8). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-STF}}^{(i_{Seg}, i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{STS} \cdot N_{\text{L-STF}}^{\text{Tone}}}} w_{T_{\text{L-STF}}}(t) \sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-26}^{26} \sum_{m=1}^{N_{STS}} \eta_{\text{L-STF},k} \left(\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX},m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m,1} S_{k,20} \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\text{Pre-HE}}(t - T_{CS,\text{HE}}(m))) \right) \quad (28\text{-}8)$$

where

$T_{CS,\text{HE}}(m)$ represents the cyclic shift for space-time stream m as defined in 28.3.10.2.2 (Cyclic shift for HE modulated fields)

$Q_k^{(i_{Seg})}$ is the spatial mapping/steering matrix for subcarrier k, in frequency segment i_{Seg} on the data symbols over tone spacing $\Delta_{F,\text{HE}}$ as defined in Table 28-12 (Timing-related constants). Refer to the descriptions in 21.3.10.11.1 (Transmission in VHT format) for examples of $Q_k^{(i_{Seg})}$.

$A_{\text{HE-LTF}}^k$ is defined in Equation (28-50)

28.3.10.4 L-LTF

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain representation of the L-LTF field shall be as specified in Equation (28-9). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-LTF}}^{(i_{Seg}, i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{TX} \cdot N_{\text{L-LTF}}^{\text{Tone}}}} w_{T_{\text{L-LTF}}}(t) \sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-26}^{26} \eta_{\text{L-LTF},k} \left(\Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}} L_{k,20} \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\text{Pre-HE}}(t - T_{GI,\text{L-LTF}} - T_{CS}^{i_{TX}})) \right) \quad (28\text{-}9)$$

$\eta_{\text{L-LTF},k}$ is a PPDU format dependent scaling factor for the L-LTF field on tone index k with the same value as $\eta_{\text{L-STF},k}$.

$N_{20\text{MHz}}$ is defined in 21.3.7.3 (Channel frequencies)

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$K_{Shift}(i) = (N_{20\text{MHz}} - 1 - 2i) \cdot 32$

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} with a value given in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

$N_{\text{L-LTF}}^{\text{Tone}}$ has the value given in Table 28-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields).

$L_{k,20}$ is defined as $L_{-26,26}$ in Equation (17-8).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain representation of the L-LTF field of contiguous 20 MHz, 40 MHz, 80 MHz and 160 MHz transmission shall be as specified in Equation (28-10). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-LTF}}^{(i_{Seg}, i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{STS} \cdot N_{\text{L-LTF}}^{\text{Tone}}}} w_{T_{\text{L-LTF}}}(t) \sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-26}^{26} \sum_{m=1}^{N_{STS}} \eta_{\text{L-LTF},k} \left(\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX},m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m,1} L_{k,20} \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\text{Pre-HE}}(t - T_{GI,\text{L-LTF}} - T_{CS,\text{HE}}(m))) \right) \quad (28\text{-}10)$$

where

$T_{CS,\text{HE}}(m)$ represents the cyclic shift for space-time stream m as defined in 28.3.10.2.2 (Cyclic shift for HE modulated fields)

$Q_k^{(i_{Seg})}$ is defined in 28.3.9 (Mathematical description of signals)

$A_{\text{HE-LTF}}^k$ is defined in Equation (28-50)

28.3.10.5 L-SIG

The L-SIG field is used to communicate rate and length information. The structure of the L-SIG field is defined in Figure 17-5 (SIGNAL field bit assignment).

In an HE PPDU, the RATE field shall be set to the value representing 6 Mb/s in the 20 MHz channel spacing column of Table 17-6 (Contents of the SIGNAL field). In a non-HT duplicate PPDU, the RATE field is defined in 17.3.4.2 (RATE field) using the L_DATARATE parameter in the TXVECTOR.

The LENGTH field shall be set to the value given by Equation (28-11).

$$\text{Length} = \left\lceil \frac{\text{TXTIME} - \textit{SignalExtension} - 20}{4} \right\rceil \times 3 - 3 - m \quad (28\text{-}11)$$

where

TXTIME (in μs) is defined in 28.4.3 (TXTIME and PSDU_LENGTH calculation).

m is 1 for an HE MU PPDU and HE ER SU PPDU, and 2 otherwise

SignalExtension is 0 μs when the TXVECTOR parameter NO_SIG_EXTN is true and is aSignalExtension as defined in Table 19-25 (HT PHY characteristics) when TXVECTOR parameter NO_SIG_EXTN is false

NOTE—The value of the LENGTH field for an HE TB PPDU is set to the value decoded from the preceding Trigger frame.

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The LSB of the binary expression of the Length value shall be mapped to B5. In a non-HT duplicate PPDU, the LENGTH field is defined in 17.3.4.3 (LENGTH field) using the L_LENGTH parameter in the TXVECTOR.

The Reserved (R) field shall be set to 0.

The Parity (P) field has the even parity of bits 0-16.

The SIGNAL TAIL field shall be set to 0.

The L-SIG field shall be encoded, interleaved, and mapped following the steps described in 17.3.5.6 (Convolutional encoder), 17.3.5.7 (Data interleaving), and 17.3.5.8 (Subcarrier modulation mapping). The stream of 48 complex numbers generated by these steps is denoted by d_k, $k = 0, \ldots, 47$ and are mapped to subcarriers [−26, 26]. In addition, values [−1, −1, −1, 1] are mapped to the extra subcarriers [−28, −27, 27, 28] of the L-SIG field of a 20 MHz HE PPDU. Subcarriers [−28, −27, 27, 28] are also BPSK modulated. Pilots shall be inserted as described in 17.3.5.9 (Pilot subcarriers).

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain waveform of the L-SIG field shall be as given by Equation (28-12).

$$r_{\text{L-SIG}}^{(i_{Seg}, i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{L-SIG}}^{\text{Tone}}}} w_{T_{\text{L-SIG}}}(t) \sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-28}^{28} \left(\begin{array}{l} \Upsilon_{(k - K_{\text{Shift}}(i_{BW})), \text{BW}} \eta_{\text{L-SIG}, k} (D_{k, 20} + p_0 P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}})) \Delta_{F, \text{Pre-HE}} (t - T_{GI, \text{Pre-HE}} - T_{CS}^{i_{TX}})) \end{array} \right) \quad (28\text{-}12)$$

where

$\eta_{\text{L-SIG}, k}$ is a PPDU dependent scaling factor for the L-SIG field on the subcarrier k defined as follows:

$$\eta_{\text{L-SIG}, k} = \begin{cases} \sqrt{2}, & k = \pm 28, \pm 27 \text{ for an HE ER SU PPDU} \\ 1, & \text{otherwise} \end{cases}$$

$N_{20\text{MHz}}$ is defined in 21.3.7.3 (Channel frequencies)

$K_{Shift}(i) = (N_{20\text{MHz}} - 1 - 2i) \cdot 32$

$$D_{k, 20} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ -1, k = -28, -27, 27 \\ 1, k = 28 \\ d_{M_{20}^r(k)}, \text{otherwise} \end{cases}$$

$$M_{20}^r(k) = \begin{cases} k + 26, -26 \le k \le -22 \\ k + 25, -20 \le k \le -8 \\ k + 24, -6 \le k \le -1 \\ k + 23, 1 \le k \le 6 \\ k + 22, 8 \le k \le 20 \\ k + 21, 22 \le k \le 26 \end{cases}$$

P_k is defined in 17.3.5.10 (OFDM modulation)

p_0 is the first pilot value in the sequence defined in 17.3.5.10 (OFDM modulation)

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$N_{\text{L-SIG}}^{\text{Tone}}$ is defined in Table 28-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields)

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} with a value given in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

NOTE—$M_{20}^{r}(k)$ is a "reverse" function of the function $M(k)$ defined in 17.3.5.10 (OFDM modulation).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform of the L-SIG field shall be as given by Equation (28-13).

$$r_{\text{L-SIG}}^{(i_{Seg}, i_{TX})}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{\text{L-SIG}}^{\text{Tone}}}} w_{T_{\text{L-SIG}}}(t) \sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-28}^{28} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX}, m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m, 1} \eta_{\text{L-SIG}, k}(D_{k, 20} + p_0 P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F, \text{Pre-HE}}(t - T_{GI, \text{Pre-HE}} - T_{CS, \text{HE}}(m))) \end{array} \right) \quad (28\text{-}13)$$

where

$T_{CS, \text{HE}}(m)$ represents the cyclic shift for space-time stream m as defined in 28.3.10.2.2 (Cyclic shift for HE modulated fields)

$Q_k^{(i_{Seg})}$ is defined in 28.3.9 (Mathematical description of signals)

$A_{\text{HE-LTF}}^{k}$ is defined in Equation (28-50)

28.3.10.6 RL-SIG

The RL-SIG field is a repeat of the L-SIG field and is used to differentiate an HE PPDU from a non-HT PPDU, HT PPDU, and VHT PPDU.

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain waveform of the RL-SIG field shall be as given by Equation (28-14).

$$r_{\text{RL-SIG}}^{(i_{Seg}, i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{RL-SIG}}^{\text{Tone}}}} w_{T_{\text{L-SIG}}}(t) \sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-28}^{28} \left(\begin{array}{l} \Upsilon_{(k-K_{\text{Shift}}(i_{BW})), \text{BW}} \eta_{\text{L-SIG}, k}(D_{k, 20} + p_1 P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F, \text{Pre-HE}}(t - T_{GI, \text{Pre-HE}} - T_{CS}^{i_{TX}})) \end{array} \right) \quad (28\text{-}14)$$

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform of the RL-SIG field shall be as given by Equation (28-15).

$$r_{\text{RL-SIG}}^{(i_{Seg}, i_{TX})}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{\text{RL-SIG}}^{\text{Tone}}}} w_{T_{\text{L-SIG}}}(t) \sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-28}^{28} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX}, m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m, 1} \eta_{\text{L-SIG}, k}(D_{k, 20} + p_1 P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F, \text{Pre-HE}}(t - T_{GI, \text{Pre-HE}} - T_{CS, \text{HE}}(m))) \end{array} \right) \quad (28\text{-}15)$$

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where

p_1 is the second pilot value in the sequence defined in 17.3.5.10 (OFDM modulation).

28.3.10.7 HE-SIG-A

28.3.10.7.1 General

The HE-SIG-A field carries information necessary to interpret HE PPDUs.

28.3.10.7.2 Content

The HE-SIG-A field for an HE SU PPDU or an HE ER SU PPDU contains the fields listed in Table 28-18 (HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU).

Table 28-18—HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
HE-SIG-A1	B0	Format	1	Differentiate an HE SU PPDU from an HE TB PPDU: Set to 0 for HE TB PPDU Set to 1 for HE SU PPDU This field is reserved and set to 1 for an HE ER SU PPDU.
	B1	Beam Change	1	Set to 1 to indicate that the pre-HE modulated fields of the PPDU are spatially mapped differently from the first symbol of the HE-LTF. Set to 0 to indicate that the pre-HE modulated fields of the PPDU are spatially mapped the same way as the first symbol of the HE-LTF on each tone.
	B2	UL/DL	1	Indicates whether the PPDU is sent UL or DL: Set to 0 for DL Set to 1 for UL This field shall be set to DL for TDLS, mesh and IBSS. NOTE—The TDLS peer can identify the TDLS frame by To DS and From DS fields in the MAC header of the MPDU.
	B3-B6	MCS	4	For an HE SU PPDU: Set to *n* for MCS*n*, where *n* = 0, 1, 2, …., 11 Values 12-15 are reserved For HE ER SU PPDU with Bandwidth field set to 0 (242-tone RU): Set to *n* for MCS*n*, where *n* = 0, 1, 2 Values 3-15 are reserved For HE ER SU PPDU with Bandwidth field set to 1 (upper frequency 106-tone RU): Set to 0 for MCS 0 Values 1-15 are reserved

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Table 28-18—HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU *(continued)*

B7	DCM	1	Indicates whether or not DCM is applied to the Data field for the MCS indicated. Set to 1 to indicate that DCM is applied to the Data field. Neither DCM nor STBC shall be applied when both the DCM and STBC are set to 1. Set to 0 to indicate that DCM is not applied to the Data field. DCM is only applied for MCS0, MCS1, MCS3 and MCS4. DCM is only applied for 1 and 2 spatial streams. DCM is not applied when STBC is used.
B8-B13	BSS Color	6	The BSS Color field is an identifier of the BSS
B14	Reserved	1	Reserved and set to 1
B15-B18	Spatial Reuse	4	Indicates whether or not spatial reuse is allowed during the transmission of this PPDU, and if allowed, indicates a value that is used to determine a limit on the transmit power of a spatial reuse transmission. Set to the value of the SPATIAL_REUSE parameter of the TXVECTOR, which contains a value from Table 28-21 (Spatial Reuse subfield encoding for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU) subfield encoding for an HE MU PPDU, HE SU PPDU or HE ER SU PPDU, see 27.11.6 (SPATIAL_REUSE). Set to SRP_DISALLOW to prohibit SRP-based spatial reuse during this PPDU. Set to SRP_AND_NON-SRG_OBSS-PD_PROHIBITED to prohibit both SRP-based spatial reuse and non-SRG OBSS-PD-based spatial reuse during this PPDU. For the interpretation of other values see 27.11.6 (SPATIAL_REUSE) and 27.9 (Spatial reuse operation).
B19-B20	Bandwidth	2	For an HE SU PPDU: Set to 0 for 20 MHz Set to 1 for 40 MHz Set to 2 for 80 MHz Set to 3 for 160 MHz and 80+80 MHz For an HE ER SU PPDU: Set to 0 for 242-tone RU Set to 1 for upper frequency 106-tone RU within the primary 20 MHz Values 2 and 3 are reserved
B21-B22	GI+LTF Size	2	Indicates the GI duration and HE-LTF size. Set to 0 to indicate a 1x HE-LTF and 0.8 μs GI Set to 1 to indicate a 2x HE-LTF and 0.8 μs GI Set to 2 to indicate a 2x HE-LTF and 1.6 μs GI Set to 3 to indicate: — a 4x HE-LTF and 0.8 μs GI if both the DCM and STBC fields are 1. Neither DCM nor STBC shall be applied when both the DCM and STBC fields are set to 1. — a 4x HE-LTF and 3.2 μs GI, otherwise

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Table 28-18—HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU *(continued)*

	B23-B25	Nsts And Midamble Periodicity	3	If the Doppler subfield is 0, indicates the number of space-time streams. For an HE SU PPDU: Set to the number of space-time streams minus 1 For an HE ER SU PPDU: Set to 0 for one space-time stream when the STBC subfield is set to 0 Set to 1 for two space-time streams when the STBC subfield is set to 1 Values 2-7 are reserved If the Doppler subfield is 1, then B23-B24 indicates the number of space time streams, up to 4, and B25 indicates the midamble periodicity. For an HE SU PPDU, B23-B24 is set to the number of space time streams minus 1. For an HE ER SU PPDU, B23-B24 is encoded as follows: 0 indicates one space time stream when the STBC subfield is set to 0 1 indicates two space time streams when the STBC subfield is set to 1 2-3 are reserved B25 is set 0 if TXVECTOR parameter MIDAMBLE_PERIODICITY is 10 and set to 1 if TXVECTOR parameter MIDAMBLE_PERIODICITY is 20.
HE-SIG-A2 (HE SU PPDU) or HE-SIG-A3 (HE ER SU PPDU)	B0-B6	TXOP	7	Set to 127 to indicate no duration information when TXVECTOR parameter TXOP_DURATION is set to UNSPECIFIED. Set to a value less than 127 to indicate duration information for NAV setting and protection of the TXOP as follows: If TXVECTOR parameter TXOP_DURATION is less than 512, then B0 is set to 0 and B1-B6 is set to floor(TXOP_DURATION/8) where B1 is the LSB. Otherwise, B0 is set to 1 and B1-B6 is set to floor ((TXOP_DURATION – 512) / 128) where B1 is the LSB. Where B0 indicates the TXOP length granularity. Set to 0 for 8 μs; otherwise set to 1 for 128 μs. B1-B6 indicates the scaled value of the TXOP_DURATION
	B7	Coding	1	Indicates whether BCC or LDPC is used: Set to 0 to indicate BCC Set to 1 to indicate LDPC
	B8	LDPC Extra Symbol Segment	1	Indicates the presence of the extra OFDM symbol segment for LDPC. Set to 1 if an extra OFDM symbol segment for LDPC is present Set to 0 if an extra OFDM symbol segment for LDPC is not present Reserved and set to 1 when the Coding field is 0.

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Table 28-18—HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU *(continued)*

	B9	STBC	1	Set to 1 if space time block coding is used. Neither DCM nor STBC shall be applied when both the DCM and STBC are set to 1. Set to 0 otherwise.
	B10	TxBF	1	Set to 1 if a Beamforming steering matrix is applied to the waveform in an SU transmission Set to 0 otherwise
	B11-B12	Pre-FEC Padding Factor	2	Indicates the pre-FEC padding factor. Set to 0 to indicate a pre-FEC padding factor of 4 Set to 1 to indicate a pre-FEC padding factor of 1 Set to 2 to indicate a pre-FEC padding factor of 2 Set to 3 to indicate a pre-FEC padding factor of 3
	B13	PE Disambiguity	1	Indicate PE Disambiguity as defined in 28.3.12 (Packet extension).
	B14	Reserved	1	Reserved and set to 1
	B15	Doppler	1	Set to 1 if one of the following applies: — The number of OFDM symbols in the HE Data field is larger than the signaled midamble periodicity plus 1 and the midamble is present — The number of OFDM symbols in the HE Data field is less than or equal to the signaled midamble periodicity plus 1 (see 28.3.11.16 Midamble), the midamble is not present, but the channel Doppler is high. It recommends that midamble may be used for the PPDUs of the reverse link. Set to 0 otherwise.
	B16-B19	CRC	4	CRC for bits 0–41 of the HE-SIG-A field (see 28.3.10.7.3 (CRC computation)). Bits 0–41 of the HE-SIG-A field correspond to bits 0–25 of HE-SIG-A1 followed by bits 0–15 of HE-SIG-A2).
	B20-B25	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

NOTE—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.

The HE-SIG-A field of an HE MU PPDU contains the fields listed in Table 28-19 (HE-SIG-A field of an HE MU PPDU).

Table 28-19—HE-SIG-A field of an HE MU PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description

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Table 28-19—HE-SIG-A field of an HE MU PPDU *(continued)*

HE-SIG-A1	B0	UL/DL	1	Indicates whether the PPDU is sent UL or DL: Set to 0 for DL, TDLS, mesh and IBSS Set to 1 for UL NOTE—The TDLS peer can identify the TDLS frame by To DS and From DS fields in the MAC header of the MPDU.
	B1-B3	SIGB MCS	3	Indicates the MCS of the HE-SIG-B field: Set to 0 for MCS 0 Set to 1 for MCS 1 Set to 2 for MCS 2 Set to 3 for MCS 3 Set to 4 for MCS 4 Set to 5 for MCS 5 The values 6 and 7 are reserved
	B4	SIGB DCM	1	Set to 1 indicates that the HE-SIG-B is modulated with dual sub-carrier modulation for the MCS. Set to 0 indicates that the HE-SIG-B is not modulated with dual sub-carrier modulation for the MCS. DCM is only applicable to MCS0, MCS1, MCS3, and MCS4.
	B5-B10	BSS Color	6	The BSS Color field is an identifier of the BSS
	B11-B14	Spatial Reuse	4	Indicates whether or not spatial reuse is allowed during the transmission of this PPDU, and if allowed, indicates a value that is used to determine a limit on the transmit power of a spatial reuse transmission. Set to the value of the SPATIAL_REUSE parameter of the TXVECTOR, which contains a value from Table 28-21 (Spatial Reuse subfield encoding for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU) (see 27.11.6 (SPATIAL_REUSE)). Set to SRP_DISALLOW to prohibit SRP-based spatial reuse during this PPDU. Set to SRP_AND_NON-SRG_OBSS-PD_PROHIBITED to prohibit both SRP-based spatial reuse and non-SRG OBSS-PD-based spatial reuse during this PPDU. For the interpretation of other values see 27.11.6 (SPATIAL_REUSE) and 27.9 (Spatial reuse operation).

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Table 28-19—HE-SIG-A field of an HE MU PPDU *(continued)*

B15-B17	Bandwidth	3	Set to 0 for 20 MHz. Set to 1 for 40 MHz. Set to 2 for 80 MHz non-preamble puncturing mode. Set to 3 for 160 MHz and 80+80 MHz non-preamble puncturing mode. Set to 4 for preamble puncturing in 80 MHz, where in the preamble only the secondary 20 MHz is punctured. Set to 5 for preamble puncturing in 80 MHz, where in the preamble only one of the two 20 MHz sub-channels in secondary 40 MHz is punctured. Set to 6 for preamble puncturing in 160 MHz or 80+80 MHz, where in the primary 80 MHz of the preamble only the secondary 20 MHz is punctured. Set to 7 for preamble puncturing in 160 MHz or 80+80 MHz, where in the primary 80 MHz of the preamble the primary 40 MHz is present.
B18-B21	Number Of HE-SIG-B Symbols Or MU-MIMO Users	4	If the SIGB Compression field is 0, indicates the number of OFDM symbols in the HE-SIG-B field minus 1. If the SIGB Compression field is 1, indicates the number of MU-MIMO users minus 1.
B22	SIGB Compression	1	Set to 1 for full bandwidth MU-MIMO. Set to 0 otherwise.
B23-B24	GI+LTF Size	2	Indicates the GI duration and HE-LTF size: Set to 0 to indicate a 4x HE-LTF and 0.8 μs GI Set to 1 to indicate a 2x HE-LTF and 0.8 μs GI Set to 2 to indicate a 2x HE-LTF and 1.6 μs GI Set to 3 to indicate a 4x HE-LTF and 3.2 μs GI
B25	Doppler	1	Set to 1 if one of the following applies: — The number of OFDM symbols in the HE Data field is larger than the signaled midamble periodicity plus 1 and the midamble is present — The number of OFDM symbols in the HE Data field is less than or equal to the signaled midamble periodicity plus 1 (see 28.3.11.16 Midamble), the midamble is not present, but the channel Doppler is high. It recommends that midamble may be used for the PPDUs of the reverse link. Set to 0 otherwise.

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Table 28-19—HE-SIG-A field of an HE MU PPDU *(continued)*

HE-SIG-A2	B0-B6	TXOP	7	Set to 127 to indicate no duration information when TXVECTOR parameter TXOP_DURATION is set to UNSPECIFIED. Set to a value less than 127 to indicate duration information for NAV setting and protection of the TXOP as follows: If TXVECTOR parameter TXOP_DURATION is less than 512, then B0 is set to 0 and B1-B6 is set to floor(TXOP_DURATION/8) where B1 is the LSB. Otherwise, B0 is set to 1 and B1-B6 is set to floor ((TXOP_DURATION – 512) / 128) where B1 is the LSB. Where B0 indicates the TXOP length granularity. Set to 0 for 8 μs; otherwise set to 1 for 128 μs. B1-B6 indicates the scaled value of the TXOP_DURATION
	B7	Reserved	1	Reserved and set to 1
	B8-B10	Number of HE-LTF Symbols And Midamble Periodicity	3	When the Doppler subfield is 0, indicates the number of HE-LTF symbols: Set to 0 for 1 HE-LTF symbol Set to 1 for 2 HE-LTF symbols Set to 2 for 4 HE-LTF symbols Set to 3 for 6 HE-LTF symbols Set to 4 for 8 HE-LTF symbols Other values are reserved. When the Doppler subfield is 1, B8-B9 indicates the number of HE-LTF symbols, up to 4, and B10 indicates midamble periodicity: B8-B9 is encoded as follows: 0 indicates 1 HE-LTF symbol 1 indicates 2 HE-LTF symbols 2 indicates 4 HE-LTF symbols 3 is reserved B10 is set to 0 if the TXVECTOR parameter MIDAMBLE_PERIODICITY is 10 and set to 0 if the TXVECTOR parameter PREAMBLE_PERIODICITY is 20.
	B11	LPDC Extra Symbol Segment	1	Indication of the presence of the extra OFDM symbol segment for LDPC. Set to 1 if an extra OFDM symbol segment for LDPC is present. Set to 0 otherwise.
	B12	STBC	1	In an HE MU PPDU where each RU includes no more than 1 user, set to 1 to indicate all RUs are STBC encoded in the payload, set to 0 to indicate all RUs are not STBC encoded in the payload. STBC is not applied in MU-MIMO RUs. STBC does not apply to HE-SIG-B. STBC is not applied in RUs that are used for MU-MIMO allocation.

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Table 28-19—HE-SIG-A field of an HE MU PPDU *(continued)*

	B13-B14	Pre-FEC Padding Factor	2	Indicates the pre-FEC padding factor. Set to 0 to indicate a pre-FEC padding factor of 4 Set to 1 to indicate a pre-FEC padding factor of 1 Set to 2 to indicate a pre-FEC padding factor of 2 Set to 3 to indicate a pre-FEC padding factor of 3
	B15	PE Disambiguity	1	Indicate PE Disambiguity as defined in 28.3.12 (Packet extension).
	B16-B19	CRC	4	CRC for bits 0-41 of the HE-SIG-A field (see 28.3.10.7.3 (CRC computation)). Bits 0-41 of the HE-SIG-A field correspond to bits 0-25 of HE-SIG-A1 followed by bits 0-15 of HE-SIG-A2).
	B20-B25	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.
NOTE—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.				

It is optional for an HE STA to receive a preamble punctured HE MU PPDU with the Bandwidth field in HE-SIG-A in the range 4 to 7. An HE STA indicates that it is capable of receiving a preamble punctured HE MU PPDU with the Bandwidth field of HE-SIG-A field in the range 4 to 7 using the Punctured Preamble Rx subfield in the HE PHY Capabilities Information field in the HE Capabilities field (see 9.4.2.237 (HE Capabilities element)).

The HE-SIG-A field for an HE TB PPDU contains the fields listed in Table 28-20 (HE-SIG-A field of an HE TB PPDU).

Table 28-20—HE-SIG-A field of an HE TB PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
HE-SIG-A1	B0	Format	1	Differentiate an HE SU PPDU from an HE TB PPDU: Set to 0 for HE TB PPDU Set to 1 for HE SU PPDU
	B1-B6	BSS Color	6	The BSS Color field is an identifier of the BSS

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Table 28-20—HE-SIG-A field of an HE TB PPDU *(continued)*

B7-B10	Spatial Reuse 1	4	Indicates whether or not spatial reuse is allowed in a subband of the PPDU during the transmission of this PPDU, and if allowed, indicates a value that is used to determine a limit on the transmit power of a spatial reuse transmission. If the Bandwidth field indicates 20 MHz, 40 MHz, or 80 MHz then this Spatial Reuse field applies to the first 20 MHz subband. If the Bandwidth field indicates 160/80+80 MHz then this Spatial Reuse field applies to the first 40 MHz subband of the 160 MHz operating band. Set to the value of the SPATIAL_REUSE(1) parameter of the TXVECTOR, which contains a value from Table 28-22 (Spatial Reuse subfield encoding for an HE TB PPDU) for an HE TB PPDU (see 27.11.6 (SPATIAL_REUSE)). Set to SRP_DISALLOW to prohibit SRP-based spatial reuse during this PPDU. Set to SRP_AND_NON-SRG_OBSS-PD_PROHIBITED to prohibit both SRP-based spatial reuse and non-SRG OBSS-PD-based spatial reuse during this PPDU. For the interpretation of other values see 27.11.6 (SPATIAL_REUSE) and 27.9 (Spatial reuse operation).
B11-B14	Spatial Reuse 2	4	Indicates whether or not spatial reuse is allowed in a subband of the PPDU during the transmission of this PPDU, and if allowed, indicates a value that is used to determine a limit on the transmit power of a spatial reuse transmission. If the Bandwidth field indicates 20 MHz, 40 MHz, or 80 MHz: This Spatial Reuse field applies to the second 20 MHz subband. When the STA operating channel width is 20 MHz, then this field is set to the same value as Spatial Reuse 1 field. When the STA operating channel width is 40 MHz in the 2.4 GHz band, this field is set to the same value as Spatial Reuse 1 field. If the Bandwidth field indicates 160/80+80 MHz the this Spatial Reuse field applies to the second 40 MHz subband of the 160 MHz operating band. Set to the value of the SPATIAL_REUSE(2) parameter of the TXVECTOR, which contains a value from Table 28-22 (Spatial Reuse subfield encoding for an HE TB PPDU) for an HE TB PPDU (see 27.11.6 (SPATIAL_REUSE)). Set to SRP_DISALLOW to prohibit SRP-based spatial reuse during this PPDU. Set to SRP_AND_NON-SRG_OBSS-PD_PROHIBITED to prohibit both SRP-based spatial reuse and non-SRG OBSS-PD-based spatial reuse during this PPDU. For the interpretation of other values see 27.11.6 (SPATIAL_REUSE) and 27.9 (Spatial reuse operation).

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Table 28-20—HE-SIG-A field of an HE TB PPDU *(continued)*

B15-B18	Spatial Reuse 3	4	Indicates whether or not spatial reuse is allowed in a subband of the PPDU during the transmission of this PPDU, and if allowed, indicates a value that is used to determine a limit on the transmit power of a spatial reuse transmission. If the Bandwidth field indicates 20 MHz, 40 MHz or 80 MHz: This Spatial Reuse field applies to the third 20 MHz subband. When the STA operating channel width is 20 MHz or 40 MHz, this field is set to the same value as Spatial Reuse 1 field. If the Bandwidth field indicates 160/80+80 MHz: This Spatial Reuse field applies to the third 40 MHz subband of the 160 MHz operating band. When the STA operating channel width is 80+80 MHz, this field is set to the same value as Spatial Reuse 1 field. Set to the value of the SPATIAL_REUSE(3) parameter of the TXVECTOR, which contains a value from Table 28-22 (Spatial Reuse subfield encoding for an HE TB PPDU) for an HE TB PPDU (see 27.11.6 (SPATIAL_REUSE)). Set to SRP_DISALLOW to prohibit SRP-based spatial reuse during this PPDU. Set to SRP_AND_NON-SRG_OBSS-PD_PROHIBITED to prohibit both SRP-based spatial reuse and non-SRG OBSS-PD-based spatial reuse during this PPDU. For the interpretation of other values see 27.11.6 (SPATIAL_REUSE) and 27.9 (Spatial reuse operation).

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Table 28-20—HE-SIG-A field of an HE TB PPDU *(continued)*

B19-B22	Spatial Reuse 4	4	Indicates whether or not spatial reuse is allowed in a subband of the PPDU during the transmission of this PPDU, and if allowed, indicates a value that is used to determine a limit on the transmit power of a spatial reuse transmission. If the Bandwidth field indicates 20 MHz, 40 MHz or 80 MHz: This Spatial Reuse field applies to the fourth 20 MHz subband. When the STA operating channel width is 20 MHz, then this field is set to the same value as Spatial Reuse 1 field. When the STA operating channel width is 40 MHz, then this field is set to the same value as Spatial Reuse 2 field. If the Bandwidth field indicates 160/80+80 MHz: This Spatial Reuse field applies to the fourth 40 MHz subband of the 160 MHz operating band. When the STA operating channel width is 80+80 MHz, then this field is set to same value as Spatial Reuse 2 field. Set to the value of the SPATIAL_REUSE(4) parameter of the TXVECTOR, which contains a value from Table 28-22 (Spatial Reuse subfield encoding for an HE TB PPDU) for an HE TB PPDU (see 27.11.6 (SPATIAL_REUSE)). Set to SRP_DISALLOW to prohibit SRP-based spatial reuse during this PPDU. Set to SRP_AND_NON-SRG_OBSS-PD_PROHIBITED to prohibit both SRP-based spatial reuse and non-SRG OBSS-PD-based spatial reuse during this PPDU. For the interpretation of other values see 27.11.6 (SPATIAL_REUSE) and 27.9 (Spatial reuse operation).
B23	Reserved	1	Reserved and set to 1. NOTE—Unlike other Reserved fields in HE-SIG-A of the HE TB PPDU, B23 does not have a corresponding bit in the Trigger frame.
B24-B25	Bandwidth	2	For HE TB PPDU: Set to 0 for 20 MHz Set to 1 for 40 MHz Set to 2 for 80 MHz Set to 3 for 160 MHz and 80+80 MHz

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Table 28-20—HE-SIG-A field of an HE TB PPDU *(continued)*

HE-SIG-A2	B0-B6	TXOP	7	Set to 127 to indicate no duration information when TXVECTOR parameter TXOP_DURATION is set to UNSPECIFIED. Set to a value less than 127 to indicate duration information for NAV setting and protection of the TXOP as follows: If TXVECTOR parameter TXOP_DURATION is less than 512, then B0 is set to 0 and B1–B6 is set to floor(TXOP_DURATION/8) where B1 is the LSB. Otherwise, B0 is set to 1 and B1-B6 is set to floor ((TXOP_DURATION – 512) / 128) where B1 is the LSB. Where B0 indicates the TXOP length granularity. Set to 0 for 8 μs; otherwise set to 1 for 128 μs. B1–B6 indicates the scaled value of the TXOP_DURATION
	B7-B15	Reserved	9	Reserved and set to value indicated in the Trigger frame
	B16-B19	CRC	4	CRC of bits 0–41 of the HE-SIG-A field. See 28.3.10.7.3 (CRC computation). Bits 0–41 of the HE-SIG-A field correspond to bits 0–25 of HE-SIG-A1 followed by bits 0–15 of HE-SIG-A2).
	B20-B25	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.
NOTE—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.				

The four Spatial Reuse fields, 1, 2, 3, and 4, are arranged in increasing order of frequency and correspond to:

— For 20 MHz one Spatial Reuse field corresponding to the entire 20 MHz (other 3 fields indicate identical values). The Spatial Reuse fields only apply to 20 MHz used in the transmission.

— For 40 MHz two Spatial Reuse fields with Spatial Reuse 3 field identical in value to the Spatial Reuse 1 field and Spatial Reuse 4 field identical in value to Spatial Reuse 2 field. The Spatial Reuse fields only apply to 20 MHz used in the transmission.

— For 80 MHz four Spatial Reuse fields for each 20 MHz sub-band

  • For an OFDMA transmission of a given BW, each of the Spatial Reuse fields that corresponds to a 20 MHz sub-band is also applicable to the 242-tone RU which is most closely aligned in frequency (in the tone-plan of that BW) with the aforementioned 20 MHz sub-band. The correspondence from an Spatial Reuse field to a 242-tone RU also holds for any RU within the 242-tone RU. The above also implies that a 20 MHz OBSS STA uses the Spatial Reuse field corresponding to its 20 MHz channel, a 40 MHz OBSS STA located on the lower frequency half of the 80 MHz BSS uses Spatial Reuse 1 field, Spatial Reuse 2 field values and a 40 MHz OBSS STA located on the upper frequency half of the 80 MHz BSS uses Spatial Reuse 3 field, Spatial Reuse 4 field values

— For 160 MHz and 80+80 MHz four Spatial Reuse fields for each 40 MHz sub-band

  • For an OFDMA transmission of a given BW, each of the Spatial Reuse fields that corresponds to a 40 MHz sub-band is also applicable to the 484-tone RU which is most closely aligned in frequency (in the tone-plan of that BW) with the aforementioned 40 MHz sub-band. The correspon-

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dence from an Spatial Reuse field to a 484-tone RU also holds for any RU within the 484-tone RU.

Table 28-21 (Spatial Reuse subfield encoding for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU) defines the encoding for the Spatial Reuse 1, Spatial Reuse 2, Spatial Reuse 3 and Spatial Reuse 4 subfields for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU.

Table 28-21—Spatial Reuse subfield encoding for an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU

Value	Meaning
0	SRP_DISALLOW
1-12	Reserved
13	SR_RESTRICTED
14	SR_DELAY
15	SRP_AND_NON-SRG_OBSS-PD_PROHIB-ITED

Table 28-22 (Spatial Reuse subfield encoding for an HE TB PPDU) defines the encoding for the Spatial Reuse 1, Spatial Reuse 2, Spatial Reuse 3 and Spatial Reuse 4 subfields for an HE TB PPDU

Table 28-22—Spatial Reuse subfield encoding for an HE TB PPDU

Value	Meaning
0	SRP_DISALLOW
1	SRP = –80 dBm
2	SRP = –74 dBm
3	SRP = –68 dBm
4	SRP = –62 dBm
5	SRP = –56 dBm
6	SRP = –50 dBm
7	SRP = –47 dBm
8	SRP = –44 dBm
9	SRP = –41 dBm
10	SRP = –38 dBm
11	SRP = –35 dBm
12	SRP = –32 dBm
13	SRP = –29 dBm
14	SRP ≥ –26 dBm

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Table 28-22—Spatial Reuse subfield encoding for an HE TB PPDU *(continued)*

Value	Meaning
15	SRP_AND_NON-SRG_OBSS-PD_PROHIB-ITED

28.3.10.7.3 CRC computation

The CRC computation defined in this subclause applies to HE-SIG-A, the Common field of HE-SIG-B, and the User Block field of HE-SIG-B.

The CRC is calculated over bits 0 to 41 of the HE-SIG-A field and over bits 0 to L of the HE-SIG-B field ($L = x$ for each Common field where $x = N \times 8$ when the Center 26-tone RU field is present, and $x = N \times 8 - 1$ otherwise, and $L = 20$ for an User Block field that contains one User field and $L = 41$ for an User Block field that contains two User fields). Bits 0 to 41 of the HE-SIG-A field correspond to bits 0–25 of HE-SIG-A1 followed by bits 0–15 of HE-SIG-A2). Refer to Table 28-23 (Common field) for N and the conditions under which the Center 26-tone RU field is present.

The value of the CRC field shall be the 1s complement of

$$crc(D) = (M(D) + I(D))D^8 mod\ G(D)$$

where

$$M(D) = \sum_{i=0}^{L} m_{L-i} D^i$$

where

$$I(D) = \sum_{i=L-7}^{L} D^i$$

$G(D)$ is defined in 19.3.9.4.4 (CRC calculation for HT-SIG).

$$crc(D) = c_0 D^7 + c_1 D^6 + \ldots + c_6 D + c_7$$

The CRC field is transmitted from *c4* to *c7* with *c7* first.

Figure 28-23 (CRC calculation) shows the operation of the CRC. First, the shift register is reset to all 1s. The bits are then passed through the XOR operation at the input. When the last bit has entered, the output is generated by shifting the bits out of the shift register, *c7* first, through an inverter.

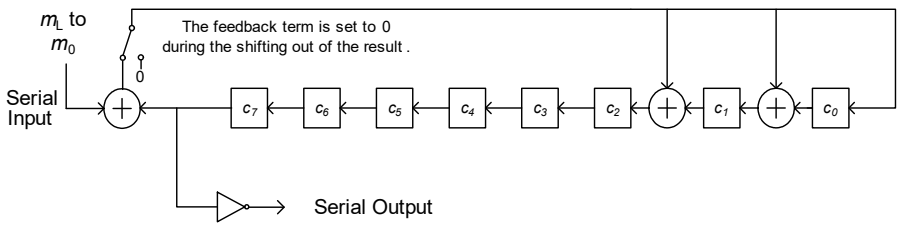


Figure 28-23—CRC calculation

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As an example, if bits $\{m_0 \ldots m_{41}\}$ are given by {1 1 0 1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 1 0 1 0}, the output bits $\{B_7 \ldots B_4\}$, where B_7 is output first, are {0 1 1 1}.

28.3.10.7.4 Encoding and modulation

For an HE SU PPDU, HE MU PPDU and HE TB PPDU, the HE-SIG-A field is composed of two parts, HE-SIG-A1 and HE-SIG-A2, each containing 26 data bits. HE-SIG-A1 is transmitted before HE-SIG-A2. The HE-SIG-A symbols shall be BCC encoded at rate, R = 1/2, interleaved, mapped to a BPSK constellation, and have pilots inserted following the steps described in 17.3.5.6 (Convolutional encoder), 28.3.11.8 (BCC interleavers), 17.3.5.8 (Subcarrier modulation mapping), and 17.3.5.9 (Pilot subcarriers), respectively. The constellation mappings of HE-SIG-A in HE SU PPDU, HE MU PPDU and HE TB PPDU are shown in Figure 28-24 (Data tone constellation of HE-SIG-A symbols). The first and second half of the stream of 104 complex numbers generated by these steps (before pilot insertion) is divided into two groups of 52 complex numbers, where respectively, the first 52 complex numbers form the first symbol of HE-SIG-A and the second 52 complex numbers form the second symbol of HE-SIG-A. If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain waveform for the HE-SIG-A field of an HE SU PPDU, HE MU PPDU and HE TB PPDU shall be as specified in Equation (28-16).

$$r_{\text{HE-SIG-A}}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{HE-SIG-A}}^{\text{Tone}}}} \sum_{n=0}^{1} w_{T_{SYML}}(t - nT_{SYML}) \sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-28}^{28} \left(\begin{array}{l} \Upsilon_{(k - K_{\text{Shift}}(i_{BW})),\, \text{BW}}(D_{k,n,20} + p_{n+2} P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - nT_{SYML} - T_{GI,\,\text{Pre-HE}} - T_{CS}^{i_{TX}})) \end{array} \right) \quad (28\text{-}16)$$

where

$N_{20\text{MHz}}$ is defined in 21.3.7.3 (Channel frequencies)

$$K_{\text{Shift}}(i) = (N_{20\text{MHz}} - 1 - 2i) \cdot 32$$

$$D_{k,n,20} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M_{20}^{r}(k),\, n}, \text{otherwise} \end{cases}$$

$$M_{20}^{r}(k) = \begin{cases} k + 28, -28 \le k \le -22 \\ k + 27, -20 \le k \le -8 \\ k + 26, -6 \le k \le -1 \\ k + 25, 1 \le k \le 6 \\ k + 24, 8 \le k \le 20 \\ k + 23, 22 \le k \le 28 \end{cases}$$

P_k and p_n are defined in 17.3.5.10 (OFDM modulation)

$N_{\text{HE-SIG-A}}^{\text{Tone}}$ is defined in Table 28-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields)

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmit chain i_{TX} with a value given in 28.3.10.2.1 (Cyclic shift for pre-HE modulated fields).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform of the HE-SIG-A field shall be as given by Equation (28-17).

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$$r_{\text{HE-SIG-A}}^{(i_{Seg}, i_{TX})}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{\text{HE-SIG-A}}^{\text{Tone}}}} \sum_{n=0}^{1} w_{T_{SYML}}(t - nT_{SYML}) \quad (28\text{-}17)$$

$$\sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-28}^{28} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX}, m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m, 1} (D_{k, n, 20} + p_{n+2} P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F, \text{Pre-HE}}(t - nT_{SYML} - T_{\text{GI, Pre-HE}} - T_{CS, HE}(m))) \end{array} \right)$$

where

$T_{CS, \text{HE}}(m)$ represents the cyclic shift for space-time stream m as defined in 28.3.10.2.2 (Cyclic shift for HE modulated fields)

$Q_k^{(i_{Seg})}$ is defined in 28.3.9 (Mathematical description of signals)

$A_{\text{HE-LTF}}^{k}$ is defined in Equation (28-50)

For an HE ER SU PPDU, the HE-SIG-A field is composed of four parts, i.e. HE-SIG-A1, HE-SIG-A2, HE-SIG-A3 and HE-SIG-A4, each part containing 26 data bits. These four parts are transmitted sequentially from HE-SIG-A1 to HE-SIG-A4. The data bits of HE-SIG-A1 and HE-SIG-A3 shall be BCC encoded at rate, R = 1/2, interleaved, mapped to a BPSK constellation, and have pilots inserted. HE-SIG-A2 has the same encoded bits as HE-SIG-A1 and the encoded bits shall be mapped to a QBPSK constellation without interleaving and have pilots inserted. The constellation mappings of the HE-SIG-A field in an HE ER SU PPDU is shown in Figure 28-24 (Data tone constellation of HE-SIG-A symbols). The QBPSK constellation on HE-SIG-A2 is used to differentiate between an HE ER SU PPDU and an HE MU PPDU when m = 1 in Equation (28-11). HE-SIG-A4 has the same encoded bits as HE-SIG-A3 and the encoded bits shall be mapped to a BPSK constellation without interleaving and have pilots inserted. BCC encoding, data interleaving, constellation mapping and pilot insertion follow the steps described in 17.3.5.6 (Convolutional encoder), 28.3.11.8 (BCC interleavers), 17.3.5.8 (Subcarrier modulation mapping), and 17.3.5.9 (Pilot subcarriers), respectively.

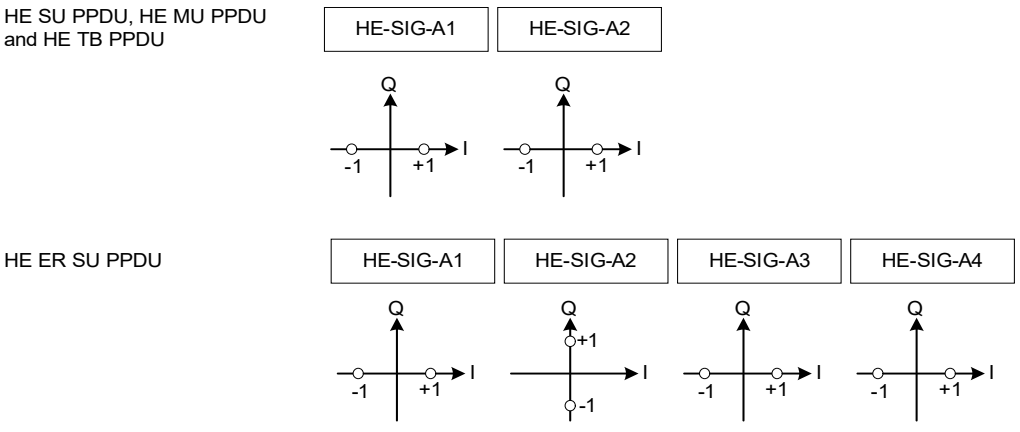


Figure 28-24—Data tone constellation of HE-SIG-A symbols

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain waveform for the HE-SIG-A field in an HE ER SU PPDU, shall be as specified in Equation (28-18).

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$$r_{\text{HE-SIG-A}}^{(i_{Seg}, i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{HE-SIG-A}}^{\text{Tone}}}} \sum_{n=0}^{3} w_{T_{\text{SYML}}}(t - nT_{SYML}) \quad (28\text{-}18)$$

$$\sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-28}^{28} \left(\begin{array}{l} \Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\,\text{BW}}(R_n D_{k,n,20} + p_{n+2} P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - nT_{SYML} - T_{GI,\,\text{Pre-HE}} - T_{CS}^{i_{TX}})) \end{array} \right)$$

where

$N_{20MHz} = 1$

R_n is a phase rotation vector defined as [1, j, 1, 1]

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform for the HE-SIG-A field in an HE ER SU PPDU, shall be as specified in Equation (28-19).

$$r_{\text{HE-SIG-A}}^{(i_{Seg}, i_{TX})}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{\text{HE-SIG-A}}^{\text{Tone}}}} \sum_{n=0}^{3} w_{T_{SYML}}(t - nT_{SYML}) \quad (28\text{-}19)$$

$$\sum_{i_{BW}=0}^{N_{20\text{MHz}}-1} \sum_{k=-28}^{28} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX},\,m} \left[A_{\text{HE-LTF}}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m,\,1} (R_n D_{k,n,20} + p_{n+2} P_k) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\,\text{Pre-HE}}(t - nT_{SYML} - T_{\text{GI,\,Pre-HE}} - T_{CS,\,HE}(m))) \end{array} \right)$$

where

$N_{20MHz} = 1$

28.3.10.8 HE-SIG-B

28.3.10.8.1 General

The HE-SIG-B field provides the OFDMA and DL MU-MIMO resource allocation information to allow the STAs to look up the corresponding resources in the data portion of the frame.

28.3.10.8.2 Encoding and modulation

The HE-SIG-B field is separately encoded on each 20 MHz band. The encoding structure in one such 20 MHz band is shown in Figure 28-25 (HE-SIG-B field encoding structure in each 20 MHz). It consists of a Common field followed by a User Specific field which together are referred to as the HE-SIG-B content channel.

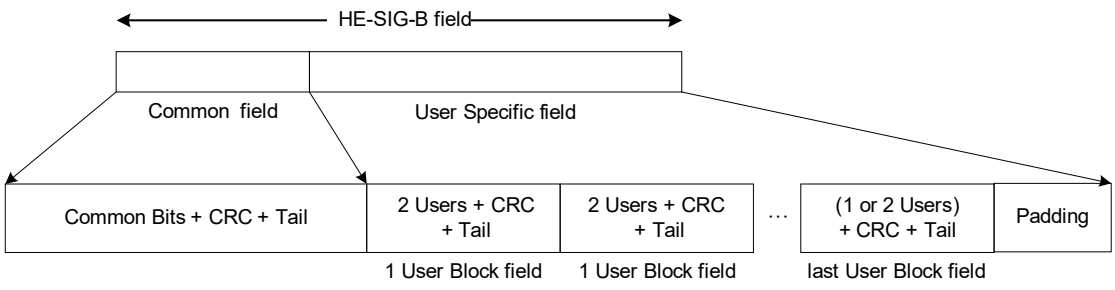


Figure 28-25—HE-SIG-B field encoding structure in each 20 MHz

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The Common field of an HE-SIG-B content channel contains information regarding the resource unit allocation such as the RU assignment in frequency domain, the RUs allocated for MU-MIMO and the number of users in MU-MIMO allocations. The Common field is described in detail in 28.3.10.8.5 (HE-SIG-B common content).

The User Specific field of an HE-SIG-B content channel consists of zero or more User Block fields followed by padding (if present). Each User Block field is made up of two User fields that contain information for two STAs to decode their payloads. The last User Block field may contain information for one or two STAs depending on the number of users indicated by the RU Allocation field and the Center 26-tone RU field. See 28.3.10.8.6 (HE-SIG-B per-user content) for a description of the contents of the User field.

When the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 1 (indicating full bandwidth MU-MIMO transmission), the Common field is not present and the HE-SIG-B content channel consists of only the User Specific field.

When the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 1 (indicating full bandwidth MU-MIMO transmission) and the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in the HE-SIG-A field of an HE MU PPDU is set to 0 (indicating 1 MU-MIMO user), the User Specific field in the HE-SIG-B field consists of a single User Block field containing one User field for a non-MU-MIMO allocation as shown in Table 28-25 (User field for a non-MU-MIMO allocation).

28.3.10.8.3 Frequency domain mapping

The 20 MHz PPDU contains one HE-SIG-B content channel in which the Common field and User Specific field are carried as shown in Figure 28-26 (HE-SIG-B content channel for a 20 MHz PPDU). The Common field contains the RU allocation signaling for RUs that occur within the 242-tone RU boundary.

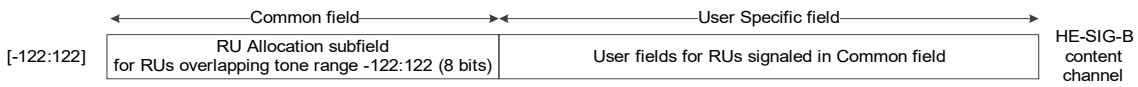


Figure 28-26—HE-SIG-B content channel for a 20 MHz PPDU

The 40 MHz PPDU contains two HE-SIG-B content channels, each occupying a 20 MHz segment. Each HE-SIG-B content channel contains a Common field followed by User Specific field as shown in Figure 28-27 (HE-SIG-B content channel for a 40 MHz PPDU). The HE-SIG-B content channels are ordered in increasing order of the absolute frequency i.e., the first HE-SIG-B content channel carries Common field and User Specific field corresponding to RUs whose subcarrier indices fall in the range [−244: −3] and the second HE-SIG-B content channel carries Common field and User Specific field corresponding to RUs whose subcarrier indices fall in the range [3:244].

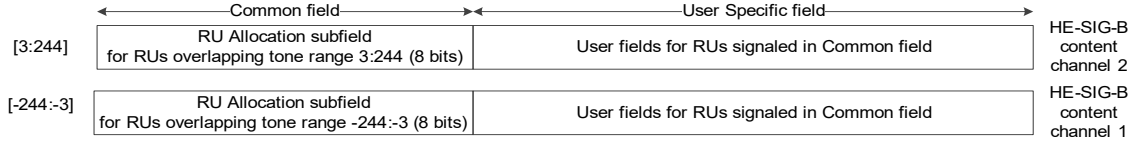


Figure 28-27—HE-SIG-B content channel for a 40 MHz PPDU

The 80 MHz PPDU contains two HE-SIG-B content channels each of which are duplicated once as shown in Figure 28-28 (Mapping of the two HE-SIG-B content channels and their duplication in an 80 MHz PPDU when the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 0). HE-SIG-B con-

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tent channel 1 occupies the tones [−500:−259] and is duplicated on tones [17: 258]. HE-SIG-B content channel 2 occupies tones [−258:−17] and is duplicated on tones [259: 500].

The first HE-SIG-B content channel appearing in the 20 MHz segments carries a Common field and User Specific field corresponding to RUs with subcarriers indices overlap those segments. The Common field of HE-SIG-B content channel 1 contains the following: an RU Allocation subfield for RUs with subcarrier indices in the range [−500:−259] or overlapping with [−500:−259] if the RU is larger than 242 subcarriers, followed by a second RU Allocation subfield for RUs with subcarrier indices between [17:258] or overlapping with [17:258] if the RU is larger than 242 subcarriers and 1 bit to indicate the presence of the User field corresponding to the center 26-tone RU that spans subcarriers [−16:−4, 4:16].

The second HE-SIG-B content channel carries a Common field and User Specific field corresponding to RUs with subcarrier indices that fall in those segments. The Common field of HE-SIG-B content channel 2 contains the following: an RU Allocation field for RUs whose subcarrier indices fall in the range [−258:−17] or overlapping with [−258:−17] if the RU is larger than 242 subcarriers, followed by a second RU Allocation field for RUs with subcarrier indices between [259:500] or overlapping with [259:500] if the RU is larger than 242 subcarriers and 1 bit to indicate presence of the User field corresponding to the center 26-tone RU that spans subcarriers [−16:−4, 4:16]. When an RU overlaps with more than one segment, it has an RU Allocation subfield for each of the segments with which it overlaps.

The same value for the bit signaling presence of the center 26-tone RU is carried in both HE-SIG-B content channels. The User fields in the User Specific field that follow the Common field are arranged in the same order as the RU allocation signaling. When assigned, the User field corresponding to the center 26-tone RU that spans subcarriers [−16:−4, 4:16] is carried as the last User field in theThe User Specific field of an HE-SIG-B content channel consists of one or more HE-SIG-B content channel 1.

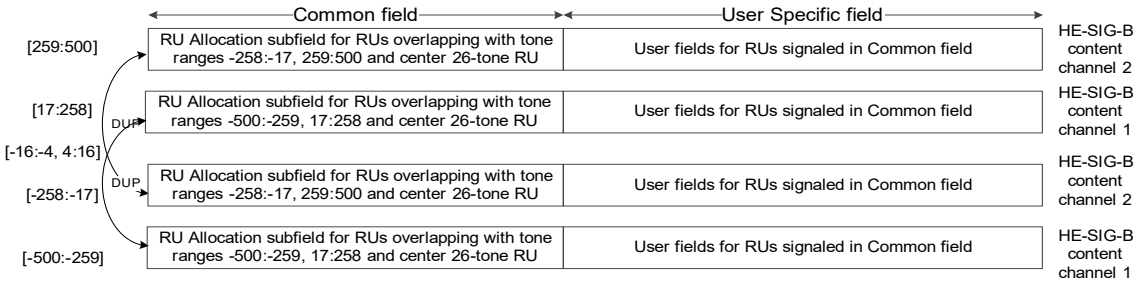


Figure 28-28—Mapping of the two HE-SIG-B content channels and their duplication in an 80 MHz PPDU when the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 0

The 160 MHz PPDU contains two HE-SIG-B content channels each of which are duplicated four times as shown in Figure 28-29 (Mapping of the two HE-SIG-B content channels and their duplication in a 160 MHz PPDU when the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 0). HE-SIG-B content channel 1 occupies subcarriers [−1012:−771] and is replicated on subcarriers [−495:−254], [12:253] and [529:770]. HE-SIG-B content channel 2 occupies subcarriers [−770:−529] and is replicated on subcarriers [−253:−12], [254:495] and [771:1012].

HE-SIG-B content channel 1 and HE-SIG-B content channel 2 carries RU allocation signaling at 242-tone RU granularity that overlap with the 20 MHz segments in which the content channels are carried (including duplication). The signaling for the presence of the User field corresponding to a center 26-tone RU in the 80 MHz segment with the lower subcarrier index is carried in HE-SIG-B content channel 1 as a 1-bit Center 26-tone RU field after the RU Allocation field in the Common field. Similarly, signaling for the center 26-tone RU in the 80 MHz segment with the higher subcarrier index is carried in HE-SIG-B content channel 2

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as 1-bit Center 26-tone RU field after the RU Allocation field in the Common field. When assigned, the User field corresponding to the center 26-tone RU in the 80 MHz segments is carried as the last User field in their respective HE-SIG-B content channels. When RUs greater than 242 subcarriers are signaled in the RU Allocation field in a portion of the bandwidth, the signaling is carried in both HE-SIG-B content channels placed in the order of the absolute subcarrier index.

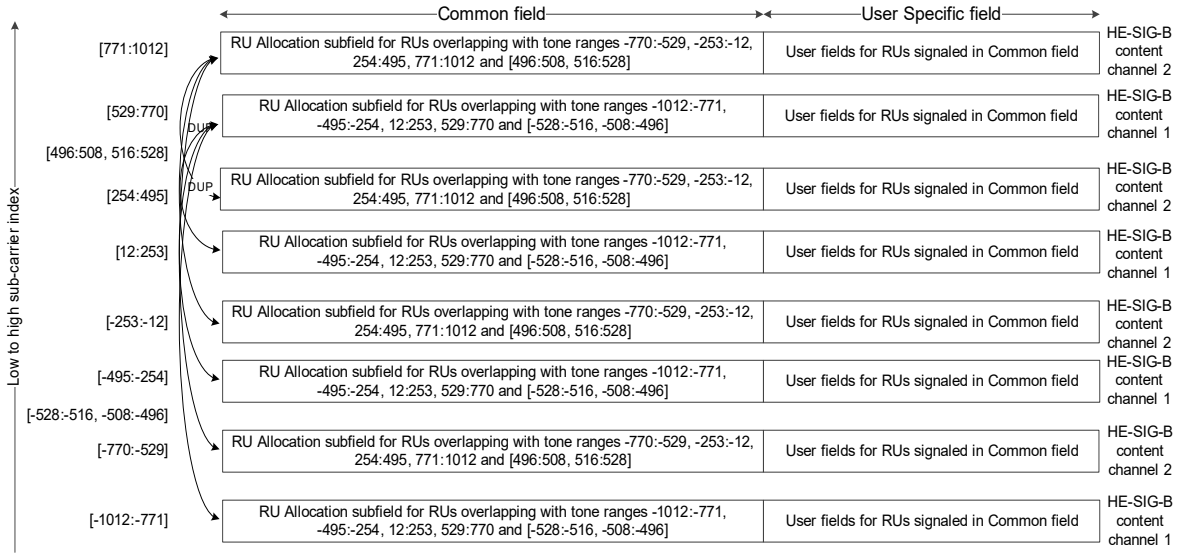


Figure 28-29—Mapping of the two HE-SIG-B content channels and their duplication in a 160 MHz PPDU when the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 0

The 80+80 MHz PPDU contains two HE-SIG-B content channels each of which are duplicated four times. The general structure is identical to the one of a 160 MHz PPDU. The only difference is that the tone ranges of the upper and lower four 20 MHz segments are not contiguous.

When preamble puncturing is present and the Bandwidth field in the HE-SIG-A field of an HE MU PPDU (see Table 28-19 (HE-SIG-A field of an HE MU PPDU)) takes values 4 or 5, the frequency domain structure of HE-SIG-B shall be the same as for an 80 MHz PPDU (see Figure 28-28 (Mapping of the two HE-SIG-B content channels and their duplication in an 80 MHz PPDU when the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 0)), but with the punctured 20 MHz channels removed.

When preamble puncturing is present and the Bandwidth field in the HE-SIG-A field of an HE MU PPDU (see Table 28-19 (HE-SIG-A field of an HE MU PPDU)) takes values 6 or 7, the frequency domain structure of HE-SIG-B shall be the same as for an 160 MHz PPDU (see Figure 28-29 (Mapping of the two HE-SIG-B content channels and their duplication in a 160 MHz PPDU when the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 0)), but with the punctured 20 MHz channels removed.

28.3.10.8.4 Time domain encoding

In each 20 MHz band, the bits in the Common field shall have CRC and tail bits appended and then be BCC encoded at rate R = ½. The CRC bits are computed as described in 28.3.10.7.3 (CRC computation). Padding is not added between the Common field and the User Specific field.

In the User Specific field, in any 20 MHz band, each User Block field shall have CRC and tail bits added and then be BCC encoded at rate $R = 1/2$. If the number of User fields in the HE-SIG-B content channel is odd,

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CRC and tail bits are added after the last User field, which is not grouped. Padding bits are appended right after the tail bits corresponding to the last User Block field in each HE-SIG-B content channel to round up to the next multiple of number of data bits per HE-SIG-B symbol, as described in 17.3.5.4 (Pad bits (PAD)). Further padding bits are appended to each HE-SIG-B content channel so that the number of OFDM symbols after encoding and modulation in the HE-SIG-B content channel equals the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in the HE-SIG-A field for an HE MU PPDU. Thus, padding ensures that the HE-SIG-B content channels in different 20 MHz bands end at the same OFDM symbol. For both the Common field and User Block field, the information bits, tail bits and padding bits (if present) are BCC encoded at rate R = ½ using the encoder described in 17.3.5.6 (Convolutional encoder). When the code rate of the HE-SIG-B MCS is not equal to ½, the convolutional encoder output bits for each field are concatenated, then the concatenated bit streams are punctured as described in 17.3.5.6 (Convolutional encoder).

The coded bits are interleaved as in 28.3.11.8 (BCC interleavers). The interleaved bits are mapped to constellation points from the MCS specified in HE-SIG-A and have pilots inserted following the steps described in 17.3.5.8 (Subcarrier modulation mapping) and 17.3.5.9 (Pilot subcarriers), respectively. Each HE-SIG-B symbol shall have 52 data tones.

The guard interval used for HE-SIG-B shall be 0.8 μs.

The number of OFDM symbols in the HE-SIG-B field, denoted by $N_{SYM,\text{HE-SIG-B}}$, shall be signaled by the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in the HE-SIG-A field of an HE MU PPDU (see 28.3.10.7.2 (Content)).

For the c-th content channel (c = 1 or 2), denote the sample on the k-th data subcarrier of the n-th symbol by $d_{k,n,c}$. The time domain waveform for the HE-SIG-B follows Equation (28-20).

$$r_{\text{HE-SIG-B}}^{(i_{Seg}, i_{TX})}(t) = \frac{1}{\sqrt{N_{TX} \cdot N_{\text{HE-SIG-B}}^{\text{Tone}}}} \sum_{n=0}^{N_{SYM,\text{ HE-SIG\_B}} - 1} w_{T_{\text{HE-SIG-B}}}(t - nT_{SYML}) \tag{28-20}$$

$$\sum_{i_{BW} \in \Omega_{20\text{MHz}}} \sum_{k=-N_{SR}}^{N_{SR}} \left(\begin{array}{l} \Upsilon_{(k - K_{\text{Shift}}(i_{BW})),\,\text{BW}} \left(\Gamma_{M_{20}^r(k)} D_{k,n,i_{BW}}^{i_{Seg}} + p_{n+4} P_k \right) \\ \cdot \exp(j2\pi(k - K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\text{ Pre-HE}}(t - nT_{SYML} - T_{GI,\text{ Pre-HE}} - T_{CS}^{i_{TX}})) \end{array} \right)$$

where

$\Gamma_{M_{20}^r(k)}$ is the phase rotation value for HE-SIG-B field PAPR reduction. When the HE-SIG-B field is modulated with MCS=0 and DCM=1, $\Gamma_{M_{20}^r(k)} = 1$. For all other modulation schemes of HE-SIG-B field,

$$\Gamma_{M_{20}^r(k)} = \begin{cases} 1 & 0 \le M_{20}^r(k) < 26 \\ (-1)^{M_{20}^r(k)} & 26 \le M_{20}^r(k) < 52 \end{cases}$$

$N_{20\text{MHz}}$is defined in 21.3.7.3 (Channel frequencies)

$K_{\text{Shift}}(i)$is defined in 21.3.8.2.4 (L-SIG definition)

$$D_{k,n,i_{BW}}^{i_{Seg}} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M_{20}^r(k),\,n,\,(i_{BW} mod\ 2)+1}, \text{otherwise} \end{cases}$$

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$$M_{20}^{r}(k) = \begin{cases} k+28, & -28 \le k \le -22 \\ k+27, & -20 \le k \le -8 \\ k+26, & -6 \le k \le -1 \\ k+25, & 1 \le k \le 6 \\ k+24, & 8 \le k \le 20 \\ k+23, & 22 \le k \le 28 \end{cases}$$

P_k and p_n are defined in 17.3.5.10 (OFDM modulation)

$N_{SYM,\,\text{HE-SIG-B}}$ is the number of OFDM symbols in the HE-SIG-B field

28.3.10.8.5 HE-SIG-B common content

The Common field in the HE-SIG-B field carries the RU Allocation subfields. Depending on the PPDU bandwidth, the Common field can contain multiple RU Allocation subfields. The format of the Common field is defined in Table 28-23 (Common field).

Table 28-23—Common field

Subfield	Number of bits	Description
RU Allocation	*N* x 8	Indicates the RU assignment in the frequency domain. It also indicates the number of users in each RU. For RUs of size greater than or equal to 106-tones that support MU-MIMO, it indicates the number of users multiplexed using MU-MIMO. Consists of *N* RU Allocation subfields: *N* = 1 for a 20 MHz and a 40 MHz HE MU PPDU *N* = 2 for an 80 MHz HE MU PPDU *N* = 4 for a 160 MHz or 80+80 MHz HE MU PPDU
Center 26-tone RU	1	This field is present only when the value of the Bandwidth field of HE-SIG-A field in an HE MU PPDU is set to greater than 1. When the Bandwidth field of the HE-SIG-A field in an HE MU PPDU is set to 2, 4 or 5 for 80 MHz: Set to 1 to indicate that a user is allocated to the center 26-tone RU (see Figure 28-7 (RU locations in an 80 MHz HE PPDU)); otherwise, set to 0. Use the same value in both HE-SIG-B content channels. When the Bandwidth field of the HE-SIG-A field in an HE MU PPDU is set to 3, 6 or 7 for 160 MHz or 80+80 MHz: For HE-SIG-B content channel 1, set to 1 to indicate that a user is allocated to the center 26-tone RU of the lower frequency 80 MHz; otherwise, set to 0. For HE-SIG-B content channel 2, set to 1 to indicate that a user is allocated to the center 26-tone RU of the higher frequency 80 MHz; otherwise, set to 0.
CRC	4	See 28.3.10.7.3 (CRC computation)
Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0
NOTE—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.		

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An RU Allocation subfield in the Common field of HE-SIG-B consists of 8 bits that indicates the following for a 20 MHz PPDU BW:

— The RU assignment in the frequency domain: indexes the size of the RUs and their placement in the frequency domain.

— The number of User fields in a 20 MHz BW within the HE-SIG-B content channel: the number of users multiplexed in the RUs indicated by the arrangement; for RUs of size greater than or equal to 106 tones that support MU-MIMO, it indicates the number of users multiplexed using MU-MIMO.

The mapping of the 8-bit RU Allocation subfield to the RU assignment and the number of users per RU is defined in the Table 28-24 (RU Allocation subfield). In the table, the number of entries column refers to the

Table 28-24—RU Allocation subfield

8 bits indices (B7 B6 B5 B4 B3 B2 B1 B0)	#1	#2	#3	#4	#5	#6	#7	#8	#9	Number of entries
00000000	26	26	26	26	26	26	26	26	26	1
00000001	26	26	26	26	26	26	26	52		1
00000010	26	26	26	26	26	52		26	26	1
00000011	26	26	26	26	26	52		52		1
00000100	26	26	52		26	26	26	26	26	1
00000101	26	26	52		26	26	26	52		1
00000110	26	26	52		26	52		26	26	1
00000111	26	26	52		26	52		52		1
00001000	52		26	26	26	26	26	26	26	1
00001001	52		26	26	26	26	26	52		1
00001010	52		26	26	26	52		26	26	1
00001011	52		26	26	26	52		52		1
00001100	52		52		26	26	26	26	26	1
00001101	52		52		26	26	26	52		1
00001110	52		52		26	52		26	26	1
00001111	52		52		26	52		52		1
00010$y_2y_1y_0$	52		52		-	106				8
00011$y_2y_1y_0$	106				-	52		52		8
00100$y_2y_1y_0$	26	26	26	26	26	106				8

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Table 28-24—RU Allocation subfield *(continued)*

8 bits indices (B7 B6 B5 B4 B3 B2 B1 B0)	#1	#2	#3	#4	#5	#6	#7	#8	#9	Number of entries
$00101y_2y_1y_0$	26	26	52		26	106				8
$00110y_2y_1y_0$	52		26	26	26	106				8
$00111y_2y_1y_0$	52		52		26	106				8
$01000y_2y_1y_0$	106				26	26	26	26	26	8
$01001y_2y_1y_0$	106				26	26	26	52		8
$01010y_2y_1y_0$	106				26	52		26	26	8
$01011y_2y_1y_0$	106				26	52		52		8
$0110y_1y_0z_1z_0$	106				-	106				16
01110000	52		52		-	52		52		1
01110001	242-tone RU empty									1
01110010	484-tone RU with no User fields in the HE-SIG-B content channel containing this RU Allocation subfield									1
01110011	996-tone RU with no User fields in the HE-SIG-B content channel containing this RU Allocation subfield									1
$011101x_1x_0$	Reserved									4
$01111y_2y_1y_0$	Reserved									8
$10y_2y_1y_0z_2z_1z_0$	106				26	106				64
$11000y_2y_1y_0$	242									8
$11001y_2y_1y_0$	484									8
$11010y_2y_1y_0$	996									8
$11011y_2y_1y_0$	2×996									8
$111x_4x_3x_2x_1x_0$	Reserved									32

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Table 28-24—RU Allocation subfield *(continued)*

8 bits indices (B7 B6 B5 B4 B3 B2 B1 B0)	#1	#2	#3	#4	#5	#6	#7	#8	#9	Number of entries
In the case of load balancing for RUs of size greater than 242-tone RU, $y_2y_1y_0$ = 000-111 indicates number of User fields in the HE-SIG-B content channel that contains the corresponding 8-bit RU Allocation subfield. Otherwise, $y_2y_1y_0$ = 000-111 indicates number of STAs multiplexed in the 106-tone RU, 242-tone RU or the lower frequency 106-tone RU if there are two 106-tone RUs and one 26-tone RU is assigned between two 106-tone RUs. The binary vector $y_2y_1y_0$ indicates $2^2 \times y_2 + 2^1 \times y_1 + y_0 + 1$ STAs multiplexed the RU. $z_2z_1z_0$ = 000-111 indicates number of STAs multiplexed in the higher frequency 106-tone RU if there are two 106-tone RUs and one 26-tone RU is assigned between two 106-tone RUs. The binary vector $z_2z_1z_0$ indicates $2^2 \times z_2 + 2^1 \times z_1 + z_0 + 1$ STAs multiplexed in the RU. Similarly, y_1y_0 = 00-11 indicates number of STAs multiplexed in the lower frequency 106-tone RU. The binary vector y_1y_0 indicates $2^1 \times y_1 + y_0 + 1$ STAs multiplexed in the RU. Similarly, z_1z_0 = 00-11 indicates the number of STAs multiplexed in the higher frequency 106-tone RU. The binary vector z_1z_0 indicates $2^1 \times z_1 + z_0 + 1$ STAs multiplexed in the RU. #1 to #9 (from left to the right) is ordered in increasing order of the absolute frequency. x_1x_0 = 00-11, $x_4x_3x_2x_1x_0$ = 00000–11111. '-' means no STA in that RU.										

number of 8-bit indices that refer to the same RU assignment in the frequency domain but differ in the number of User fields per RU. The RU assignment and the number of User fields per RU together indicate the number of User fields in the User Specific field of HE-SIG-B. Signaling for the center 26-tone RU in BW ≥ 80 MHz follows the RU Allocation subfields. When the Bandwidth field of the HE-SIG-A field in an HE MU PPDU is set to 2, 4 or 5 for 80 MHz, 1 bit is added to indicate if a user is allocated to the center 26-tone RU. The bit has the same value for both HE-SIG-B content channels. When the Bandwidth field of HE-SIG-A field in an HE MU PPDU is set to 3, 6 or 7 for 160 MHz or 80+80 MHz, 1 bit in HE-SIG-B content channel 1 indicates whether a user is allocated to the center 26-tone RU of lower frequency 80 MHz, and 1 bit in HE-SIG-B content channel 2 indicates if a user is allocated to the center 26-tone RU of higher frequency 80 MHz.

The number of RU Allocation subfields in the Common field depends on the PPDU bandwidth

— When the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 0, for a 20 MHz and a 40 MHz PPDU, each HE-SIG-B content channel contains one RU Allocation subfield in the Common field followed by multiple User fields. The position of the User field in the User Specific field together with the 8-bit RU Allocation subfield indicates the RU assignment to each user.

— When the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 0 for an 80 MHz PPDU, each HE-SIG-B content channel contains two RU Allocation subfields for a total of 16 bits of RU allocation signaling, one each for the RUs in the two 20 MHz segments of the HE-SIG-B content channel. The position of the User field in the User Specific field together with the 8-bit RU Allocation subfield indicates the RU assignment to each user. The User fields corresponding to the first RU Allocation subfield are followed by the User fields indicated by the second RU Allocation subfield in the User Specific field.

— When the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 0 for a 160 MHz PPDU, each HE-SIG-B content channel contains four RU Allocation subfields for a total of 32 bits of RU allocation signaling, one each for the RUs in the four 20 MHz segments of the HE-SIG-B content channel. The position of the User field in the User Specific field together with the 8-bit RU Allocation subfield indicates the RU assignment to each user. The User fields for each of the 20

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MHz segments in the content channel are arranged by the order in which their RU Allocation subfields appear in the Common field.

28.3.10.8.6 HE-SIG-B per-user content

The User Specific field consists of multiple User fields. The User fields follow the Common field of HE-SIG-B. The RU Allocation field in the Common field and the position of the User field in the User Specific field together identify the RU used to transmit a STA's data. Multiple RUs addressed to a single STA shall not be allowed in the User Specific field. Therefore, the signaling that enables STAs to decode its data is carried in only one User field. An example for the mapping of the 8-bit RU Allocation subfield and the position of the User field to a STA's data is illustrated in Figure 28-30 (Illustration for the mapping of the 8-bit RU Allocation subfield and the position of the User field to the STA's assignment for one 20 MHz channel). The RU Allocation subfield indicates an arrangement of 106-tone RU followed by five 26-tone RUs and that the 106-tone RU contains three User fields, i.e., the 106-tone RU supports multiplexing of three users using MU-MIMO. The eight User fields in the User Specific field thus map to the 6 RUs, with the first three User fields indicating MU-MIMO allocations in the first 106-tone RU followed by User fields corresponding to the each of the five 26-tone RUs.

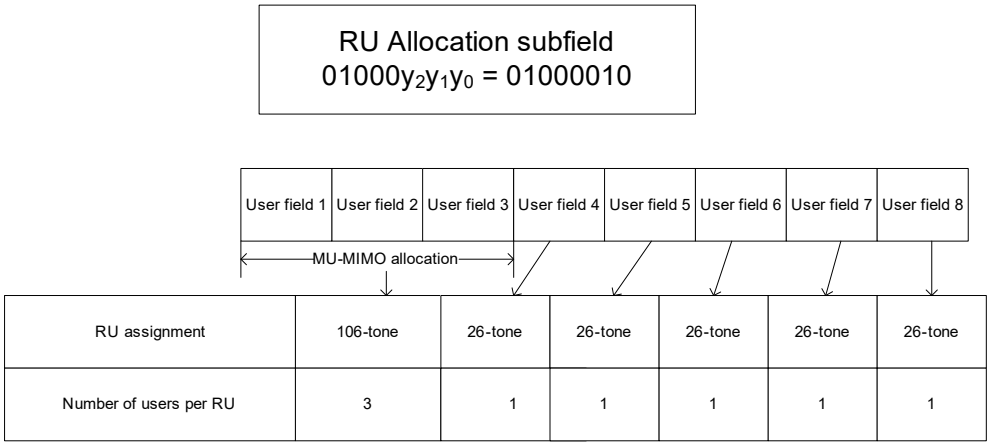


Figure 28-30—Illustration for the mapping of the 8-bit RU Allocation subfield and the position of the User field to the STA's assignment for one 20 MHz channel

The contents of the User field differ depending on whether the field addresses a STA in a non-MU-MIMO allocation in an RU or a STA in an MU-MIMO allocation in an RU. Irrespective of whether the allocation is for a STA in a non-MU-MIMO or an MU-MIMO allocation, the size of the User field is the same.

The User field for a non-MU-MIMO allocation contains the subfields shown in Table 28-25 (User field for a non-MU-MIMO allocation).

Table 28-25—User field for a non-MU-MIMO allocation

Bit	Field	Number of bits	Description
B0–B10	STA-ID	11	Set to a value of the element indicated from TXVECTOR parameter STA_ID_LIST (see 27.11.1 (STA_ID_LIST)).

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Table 28-25—User field for a non-MU-MIMO allocation *(continued)*

B11–B13	NSTS	3	Number of spatial streams. Set to the number of space-time streams minus 1.
B14	Tx Beam-forming	1	Use of transmit beamforming. Set to 1 if a beamforming steering matrix is applied to the waveform in an SU transmission. Set to 0 otherwise.
B15–B18	MCS	4	Modulation and coding scheme Set to *n* for MCS*n*, where *n* = 0, 1 ,2 …., 11 Values 12 to 15 are reserved
B19	DCM	1	Indicates whether or not dual carrier modulation is used. Set to 1 to indicate that the HE-Data portion of the corresponding user of the HE MU PPDU is modulated with dual carrier modulation for the MCS. Set to 0 indicates that the payload of the PPDU is not modulated with dual carrier modulation for the MCS.
B20	Coding	1	Indicates whether BCC or LDPC is used. Set to 0 for BCC Set to 1 for LDPC
NOTE—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.			

The User field for an MU-MIMO allocation contains the subfields shown in Table 28-26 (User field for an MU-MIMO allocation).

Table 28-26—User field for an MU-MIMO allocation

Bit	Field	Number of bits	Description
B0–B10	STA-ID	11	Set to a value of element indicated from TXVECTOR parameter STA_ID_LIST (see 27.11.1 (STA_ID_LIST)).
B11–B14	Spatial Con-figuration	4	Indicates the number of spatial streams for a STA in an MU-MIMO allocation (see Table 28-27 (Spatial Con-figuration field encoding)).
B15–B18	MCS	4	Modulation and coding scheme. Set to *n* for MCS*n*, where *n* = 0, 1, 2,…, 11 Values 12 to 15 are reserved
B19	Reserved	1	Reserved and set to 0

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Table 28-26—User field for an MU-MIMO allocation *(continued)*

B20	Coding	1	Indicates whether BCC or LDPC is used. Set to 0 for BCC Set to 1 for LDPC
NOTE—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.			

A User field for an MU-MIMO allocation includes a 4-bit Spatial Configuration field that indicates the number of spatial streams for each STA and the total number of spatial streams in the MU-MIMO allocation. The subfield shown in Table 28-27 (Spatial Configuration field encoding) is constructed by using the entries corresponding to the value of number of users (N_{user}) multiplexed using MU-MIMO in an RU. When MU-MIMO is used in an RU of size less than or equal to 242 subcarriers, the number of users (N_{user}) in an MU-MIMO allocation is equal to the number of User fields per RU signaled for the RU in the RU Allocation subfield of a Common field. When MU-MIMO is used in RUs of size greater than 242 subcarriers, the number of users (N_{user}) in an MU-MIMO allocation is computed as the sum of the number of User fields per RU indicated for the RU by the 8-bit RU Allocation subfield in each HE-SIG-B content channel. For a given value of N_{user}, the four bits of the Spatial Configuration field are used as follows: A STA with a STA-ID that matches the 11-bit ID signaled in the User field for an MU-MIMO allocation derives the number of spatial streams allocated to it using the row corresponding to the signaled 4-bit Spatial Configuration field and the column corresponding to the User field position in the User Specific field. The starting stream index for the STA is computed by summing the Nsts in the columns prior to the column indicated by the STA's User field position. In the case of load balancing for RUs of size greater than 242 subcarriers where User fields corresponding to the same MU-MIMO allocations are split into two HE-SIG-B content channels, the User field positions are logically continuous with the first User field corresponding to the same RU in the second HE-SIG-B content channel updating its position (and therefore, column index) from that of the last User field in the first HE-SIG-B content channel.

Table 28-27—Spatial Configuration field encoding

N_{user}	B3...B0	Nsts [1]	Nsts [2]	Nsts [3]	Nsts [4]	Nsts [5]	Nsts [6]	Nsts [7]	Nsts [8]	Total Nsts	Number of entries
2	0000–0011	1–4	1							2–5	10
	0100–0110	2–4	2							4–6	
	0111–1000	3–4	3							6–7	
	1001	4	4							8	
3	0000–0011	1–4	1	1						3–6	13
	0100–0110	2–4	2	1						5–7	
	0111–1000	3–4	3	1						7–8	
	1001–1011	2–4	2	2						6–8	
	1100	3	3	2						8	

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Table 28-27—Spatial Configuration field encoding *(continued)*

N_{user}	B3...B0	Nsts [1]	Nsts [2]	Nsts [3]	Nsts [4]	Nsts [5]	Nsts [6]	Nsts [7]	Nsts [8]	Total Nsts	Number of entries
4	0000–0011	1–4	1	1	1					4–7	11
	0100–0110	2–4	2	1	1					6–8	
	0111	3	3	1	1					8	
	1000–1001	2–3	2	2	1					7–8	
	1010	2	2	2	2					8	
5	0000–0011	1–4	1	1	1	1				5–8	7
	0100–0101	2–3	2	1	1	1				7–8	
	0110	2	2	2	1	1				8	
6	0000–0010	1–3	1	1	1	1	1			6–8	4
	0011	2	2	1	1	1	1			8	
7	0000–0001	1–2	1	1	1	1	1	1		7–8	2
8	0000	1	1	1	1	1	1	1	1	8	1

When the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 1 (indicating full bandwidth MU-MIMO transmission), the number of STAs in the MU-MIMO group is indicated in the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in the HE-SIG-A field.

When the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 0, for an MU-MIMO allocation of RU size greater than 242 subcarriers, the User fields are dynamically split between HE-SIG-B content channel 1 and HE-SIG-B content channel 2 and the split is decided by the AP (on a per case basis). See 28.3.10.8.5 (HE-SIG-B common content) and 28.3.10.8.6 (HE-SIG-B per-user content) for more details.

When the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 1, for bandwidths larger than 20 MHz, the User fields are split equitably between two HE-SIG-B content channels, i.e., for a k user MU-MIMO PPDU, 1, …, $\lceil k/2 \rceil$ User fields are carried in HE-SIG-B content channel 1 and $\lceil k/2 \rceil + 1$, …, k User fields in HE-SIG-B content channel 2.

The total number of spatial streams (total N_{STS}) is computed by summing all columns for the row signaled by the Spatial Configuration field and is indicated in Table 28-27 (Spatial Configuration field encoding) under the column Total Nsts.

28.3.10.9 HE-STF

The main purpose of the HE-STF field is to improve automatic gain control estimation in a MIMO transmission. The duration of the HE-STF field for HE PPDUs that are not HE TB PPDUs is $T_{\text{HE-STF-NT}}$ (periodicity of 0.8 μs with 5 periods) and the duration of the HE-STF field for an HE TB PPDU is $T_{\text{HE-STF-T}}$ (periodicity of 1.6 μs with 5 periods).

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For the HE-STF field, the M sequence is defined by Equation (28-21).

$$M = \{-1, -1, -1, 1, 1, 1, -1, 1, 1, 1, -1, 1, 1, -1, 1\} \quad (28\text{-}21)$$

The HE-STF field is constructed from the M sequence(s) multiplied by $(1+j)/\sqrt{2}$ or $(-1-j)/\sqrt{2}$ and extra coefficients selected out of $(1+j)/\sqrt{2}$ or $(-1-j)/\sqrt{2}$ at tone indices which are null but shall have the HE-STF coefficients after mapping M sequences to each 20 MHz subchannel.

For a 20 MHz transmission, the frequency domain sequence for HE PPDUs that are not HE TB PPDUs is given by Equation (28-22).

$$\begin{aligned} HES_{-112:16:112} &= \{M\} \cdot (1+j)/\sqrt{2} \\ HES_0 &= 0 \end{aligned} \quad (28\text{-}22)$$

where $HES_{a:b:c}$ means coefficients of the HE-STF on every b tone indices from a to c tone indices and coefficients on other tone indices are set to zero.

For a 40 MHz transmission, the frequency domain sequence for HE PPDUs that are not HE TB PPDUs is given by Equation (28-23).

$$HES_{-240:16:240} = \{M, 0, -M\} \cdot (1+j)/\sqrt{2} \quad (28\text{-}23)$$

For an 80 MHz transmission, the frequency domain sequence for HE PPDUs that are not HE TB PPDUs is given by Equation (28-24).

$$HES_{-496:16:496} = \{M, 1, -M, 0, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \quad (28\text{-}24)$$

For a 160 MHz transmission, the frequency domain sequence for HE PPDUs that are not HE TB PPDUs is given by Equation (28-25).

$$HES_{-1008:16:1008} = \{M, 1, -M, 0, -M, 1, -M, 0, -M, -1, M, 0, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \quad (28\text{-}25)$$

For an 80+80 MHz transmission, the lower 80 MHz segment for HE PPDUs that are not HE TB PPDUs shall use the HE-STF pattern for the 80 MHz defined in Equation (28-24).

For an 80+80 MHz transmission, the frequency domain sequence of the upper 80 MHz segment for HE PPDUs that are not HE TB PPDUs is given by Equation (28-26).

$$HES_{-496:16:496} = \{-M, -1, M, 0, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \quad (28\text{-}26)$$

For a 20 MHz transmission, the frequency domain sequence for HE TB PPDUs is given by Equation (28-27).

$$HES_{-120:8:120} = \{M, 0, -M\} \cdot (1+j)/\sqrt{2} \quad (28\text{-}27)$$

For a 40 MHz transmission, the frequency domain sequence for HE TB PPDUs is given by Equation (28-28).

$$\begin{aligned} HES_{-248:8:248} &= \{M, -1, -M, 0, M, -1, M\} \cdot (1+j)/\sqrt{2} \\ HES_{\pm 248} &= 0 \end{aligned} \quad (28\text{-}28)$$

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For an 80 MHz transmission, the frequency domain sequence for HE TB PPDUs is given by Equation (28-29).

$$HES_{-504:8:504} = \{M, -1, M, -1, -M, -1, M, 0, -M, 1, M, 1, -M, 1, -M\} \cdot (1+j)/\sqrt{2}$$
$$HES_{\pm 504} = 0 \tag{28-29}$$

For a 160 MHz transmission, the frequency domain sequence for HE TB PPDUs is given by Equation (28-30).

$$HES_{-1016:8:1016} = \{M, -1, M, -1, -M, -1, M, 0, -M, 1, M, 1, -M, 1, -M, 0$$
$$-M, 1, -M, 1, M, 1, -M, 0, -M, 1, M, 1, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \tag{28-30}$$
$$HES_{\pm 8} = 0, HES_{\pm 1016} = 0$$

For an 80+80 MHz transmission, the lower 80 MHz segment for HE TB PPDUs shall use the HE-STF pattern for the 80 MHz defined in Equation (28-29).

For an 80+80 MHz transmission, the frequency domain sequence of the upper 80 MHz segment for HE TB PPDUs is given by Equation (28-31).

$$HES_{-504:8:504} = \{-M, 1, -M, 1, M, 1, -M, 0, -M, 1, M, 1, -M, 1, -M\} \cdot (1+j)/\sqrt{2}$$
$$HES_{\pm 504} = 0 \tag{28-31}$$

For an OFDMA transmission, the coefficients in Equation (28-22) to Equation (28-31) are set to zero if those values are corresponding to tone indices that fall within RUs that have no users assigned to them.

The time domain representation of the signal for an HE PPDU that is not an HE TB PPDU on frequency segment i_{Seg} and transmit chain i_{TX} shall be as specified in Equation (28-32).

$$r_{\text{HE-STF}}^{(i_{Seg}, i_{TX})}(t) = w_{T_{\text{HE-STF-NT}}}(t) \cdot \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r \beta_r}{\sqrt{N_{STS,r,total}}}$$
$$\sum_{k \in K_r} \eta_{\text{HE-STF},k} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left(\left[Q_k^{(i_{Seg})} \right]_{i_{TX}, M_{r,u}+m} HES_k \cdot \exp(j2\pi k \Delta_{F,\text{HE}}(t - T_{CS,HE}(M_{r,u}+m))) \right) \tag{28-32}$$

where

α_r is the power boost factor for the r-th RU. A STA shall support α_r in the range [0.7, $\sqrt{2}$]. A STA may support α_r in the range [0.5, 2].

$\eta_{\text{HE-STF},k}$ is an HE PPDU format dependent scaling factor, defined by

$$\eta_{\text{HE-STF},k} = \begin{cases} \sqrt{2}, & \text{for an HE extended range SU PPDU} \\ 1, & \text{otherwise} \end{cases}$$

β_r is the per-RU power normalization factor and defined by

$$\beta_r = \left(\sqrt{\frac{|K_r|}{|K_r^{\text{HE-STF}}|}} \right) / \left(\sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|} \right)$$

$|K_r|$ is the cardinality of the set of subcarriers K_r

$K_r^{\text{HE-STF}}$ is the set of subcarriers that have non-zero values within K_r in the HE-STF field

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$T_{CS,\,\mathrm{HE}}(M_{r,\,u}+m)$ represents the cyclic shift for space-time stream $M_{r,u}+m$ as defined in 28.3.10.2.2 (Cyclic shift for HE modulated fields)

$Q_k^{(i_{Seg})}$ is defined in 28.3.9 (Mathematical description of signals)

$w_{T_{\mathrm{HE\text{-}STF\text{-}NT}}}$ is the windowing function for HE-STF field in the non-HE TB PPDU

The time domain representation of the signal for an HE TB PPDU transmitted by user u in the r-th RU on frequency segment i_{Seg} and transmit chain i_{TX} shall be as specified in Equation (28-33).

$$r_{\mathrm{HE\text{-}STF}}^{(i_{Seg},\,i_{TX})}(t) = \frac{1}{\sqrt{\left|K_r^{\mathrm{HE\text{-}STF}}\right| N_{STS,\,r,\,total}}} w_{T_{\mathrm{HE\text{-}STF\text{-}T}}}(t) \sum_{k\,\in\,K_r}\sum_{m\,=\,1}^{N_{STS,\,r,\,u}} \left(\left[Q_{k,\,u}^{(i_{Seg})} \right]_{i_{TX},\,m} HES_k \cdot \exp(j2\pi k\Delta_{F,\,\mathrm{HE}}(t - T_{CS,\,HE}(M_{r,\,u}+m))) \right) \quad (28\text{-}33)$$

where

$w_{T_{\mathrm{HE\text{-}STF\text{-}T}}}$ is the windowing function for HE-STF field in the HE TB PPDU

$Q_{k,\,u}^{(i_{Seg})}$ is defined in 28.3.9 (Mathematical description of signals)

It is recommended that the spatial mapping matrix applied to HE-STF and beyond is chosen such that it preserves the smoothness of the physical channel, achieved by limiting the variation of each element's real and imaginary values in the spatial mapping matrix across successive tones within one RU.

28.3.10.10 HE-LTF

The HE-LTF field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. In an HE SU PPDU, HE ER SU PPDU and HE MU PPDU, the transmitter provides training for $N_{STS,r,total}$ space-time streams (spatial mapper inputs) used for the transmission of the PSDU(s) in the r-th RU. In an HE TB PPDU, the transmitter of user u in the r-th RU provides training for $N_{STS,r,u}$ space-time streams used for the transmission of the PSDU. For each tone in the r-th RU, the MIMO channel that can be estimated is an $N_{RX} \times N_{STS,r,total}$ matrix. An HE transmission has a preamble that contains HE-LTF symbols, where the data tones of each HE-LTF symbol are multiplied by entries belonging to a matrix $P_{\mathrm{HE\text{-}LTF}}$, to enable channel estimation at the receiver. The pilot subcarriers of each HE-LTF symbol are multiplied by the entries of a matrix $R_{\mathrm{HE\text{-}LTF}}$ defined in the following text. The multiplication of the pilot subcarriers in the HE-LTF symbol by the $R_{\mathrm{HE\text{-}LTF}}$ matrix instead of the $P_{\mathrm{HE\text{-}LTF}}$ matrix allows receivers to track phase and frequency offset during MIMO channel estimation using the HE-LTF. In an HE SU PPDU, HE ER SU PPDU and HE MU PPDU with a single RU (the RU having an MU-MIMO allocation or an SU allocation), the number of HE-LTF symbols, $N_{\mathrm{HE\text{-}LTF}}$, is a function of the total number of space-time streams N_{STS} as shown in Table 21-13 (Number of VHT-LTFs required for different numbers of space-time streams) in 21.3.8.3.5 (VHT-LTF definition), replacing $N_{VHT\text{-}LTF}$ by $N_{HE\text{-}LTF}$. In an HE TB PPDU, $N_{\mathrm{HE\text{-}LTF}}$ is indicated in the Trigger frame that triggers the transmission of the PPDU. In an HE MU PPDU, $N_{\mathrm{HE\text{-}LTF}}$ is indicated in the HE-SIG-A field. In an HE MU PPDU with more than one RU and in an HE TB PPDU, $N_{\mathrm{HE\text{-}LTF}}$ may take any value among one, two, four, six or eight, which is greater than or equal to the maximum value of the initial number of HE-LTF symbols for each RU r, which is calculated as a function of $N_{STS,r,total}$, separately based on Table 21-13 (Number of VHT-LTFs required for different numbers of space-time streams) in 21.3.8.3.5 (VHT-LTF definition), replacing $N_{VHT\text{-}LTF}$ by $N_{HE\text{-}LTF}$.

An HE PPDU supports 3 HE-LTF modes, which are 1x HE-LTF, 2x HE-LTF and 4x HE-LTF. It is optional to support the 1x HE-LTF in an HE SU PPDU and HE ER SU PPDU. It is mandatory to support 1x HE-LTF for full bandwidth UL MU-MIMO, for a STA declaring support for UL MU-MIMO. The 1x HE-LTF is dis-

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allowed in an HE MU PPDU and in an HE TB PPDU with more than one RU. In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, the combination of HE-LTF modes and GI duration is indicated in HE-SIG-A field. In an HE TB PPDU, the combination of HE-LTF modes and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU.

If an HE PPDU is an HE NDP PPDU, the combinations of HE-LTF modes and GI durations are listed in 28.3.16 (HE sounding NDP PPDU). If an HE PPDU is an HE TB NDP feedback PPDU, the combinations of HE-LTF modes and GI durations are listed in 28.3.17. Otherwise, the mandatory combinations of HE-LTF modes and GI duration are:

— 2x HE-LTF, $T_{GI1,Data}$
— 2x HE-LTF, $T_{GI2,Data}$
— 4x HE-LTF, $T_{GI4,Data}$
— 1x HE-LTF, $T_{GI2,Data}$ in a non-OFDMA, MU-MIMO HE TB PPDU

The optional combinations of HE-LTF mode and GI duration are:

— 1x HE-LTF, $T_{GI1,Data}$ in an HE SU PPDU or HE ER SU PPDU
— 4x HE-LTF, $T_{GI1,Data}$ in an HE SU PPDU, HE ER SU PPDU, or HE MU PPDU

The duration of each HE-LTF symbol excluding GI is $T_{\text{HE-LTF}}$, defined in Equation (28-34). In an HE SU PPDU, HE MU PPDU or HE ER SU PPDU, the combination of HE-LTF mode and GI duration is indicated in HE-SIG-A field. In an HE TB PPDU, the combination of HE-LTF mode and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU.

$$T_{\text{HE-LTF}} = \begin{cases} T_{\text{HE-LTF-1X}}, \text{ if 1x HE-LTF} \\ T_{\text{HE-LTF-2X}}, \text{ if 2x HE-LTF} \\ T_{\text{HE-LTF-4X}}, \text{ if 4x HE-LTF} \end{cases} \quad (28\text{-}34)$$

where $T_{\text{HE-LTF-1X}}$, $T_{\text{HE-LTF-2X}}$, $T_{\text{HE-LTF-4X}}$ are defined in Table 28-12 (Timing-related constants).

In a 20 MHz transmission, the 1x HE-LTF sequence transmitted on subcarriers [−122: 122] is given by Equation (28-35).

$$\begin{aligned} HELTF_{-122,122} = \\ &\{0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, \\ &0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, - \\ &1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, \\ &-1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, \\ &-1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, \\ &0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, \\ &0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, \\ &0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0\} \end{aligned} \quad (28\text{-}35)$$

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In a 20 MHz transmission, the 2x HE-LTF sequence transmitted on subcarriers [−122: 122] is given by Equation (28-36).

$HELTF_{-122,122}$ =

{−1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1,
0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1,
0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1,
0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, +1,
0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, 0, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1,
0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1,
0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1,
0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1,
0, −1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1} (28-36)

In a 20 MHz transmission, the 4x HE-LTF sequence transmitted on subcarriers [−122: 122] is given by Equation (28-37).

$HELTF_{-122,122}$ =

{−1, −1, +1, −1, +1, −1, +1, +1, +1, −1, +1, +1, +1, −1, −1, +1, −1, −1, −1, −1, −1, +1,
+1, −1, −1, −1, −1, +1, +1, −1, +1, −1, +1, +1, +1, +1, −1, +1, −1, −1, +1, +1, −1, +1, +1,
+1, +1, −1, −1, +1, −1, −1, −1, +1, +1, +1, +1, −1, +1, +1, −1, −1, −1, −1, +1, −1, −1, +1,
+1, −1, +1, −1, −1, −1, −1, +1, −1, +1, −1, −1, −1, −1, −1, −1, +1, +1, −1, −1, −1, −1, −
1, +1, −1, −1, +1, +1, +1, −1, +1, +1, +1, −1, +1, −1, +1, −1, −1, −1, −1, −1, +1, +1, +1,
−1, −1, −1, +1, −1, +1, +1, +1, 0, 0, 0, −1, +1, −1, +1, −1, +1, +1, −1, +1, +1, +1, −1, −1,
+1, −1, −1, +1, −1, +1, −1, +1, +1, +1, −1, +1, +1, +1, −1, −1, +1, −1, −1, −1, −1, −1, +1,
+1, −1, −1, −1, −1, −1, −1, +1, −1, +1, −1, −1, −1, −1, +1, −1, +1, +1, −1, −1, +1, −1, −
1, −1, −1, +1, +1, −1, +1, +1, +1, +1, +1, +1, +1, −1, +1, +1, −1, −1, −1, −1, +1, −1, −1,
+1, +1, −1, +1, −1, −1, −1, −1, +1, −1, +1, −1, −1, +1, +1, +1, +1, −1, −1, +1, +1, +1, +1,
+1, −1, +1, +1, −1, −1, −1, +1, −1, −1, −1, +1, −1, +1, −1, +1, +1} (28-37)

In a 40 MHz transmission, the 1x HE-LTF sequence transmitted on subcarriers [−244: 244] is given by Equation (28-38).

$HELTF_{-244,244}$ =

{+1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0,
0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0,
0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1,
0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −
1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0,
−1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0,
0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0,
0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, 0, 0, 0, 0, +1, 0,
0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1,
0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −
1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0,
−1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0,
0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0,
0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1,
0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0,
+1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1} (28-38)

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In a 40 MHz transmission, the 2x HE-LTF sequence transmitted on subcarriers [–244: 244] is given by Equation (28-39).

$HELTF_{-244,244}$ =

{+1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1,
0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1,
0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1,
0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1,
0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, +1, 0, +1,
0, +1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1,
0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1,
0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1,
0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, 0, 0, 0, 0, 0, 0, −1, 0, −1, 0, − (28-39)
1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0,
−1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0,
+1, 0, +1, 0, −1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0,
−1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0,
+1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0,
+1, 0, +1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0,
−1, 0, +1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, −1, 0, −1, 0, −1, 0, −1, 0, −1, 0, +1, 0,
+1, 0, −1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, −1, 0, +1, 0,
−1, 0, −1, 0, +1, 0, −1, 0, +1, 0, −1, 0, +1}

In a 40 MHz transmission, the 4x HE-LTF sequence transmitted on subcarriers [–244: 244] is given by Equation (28-40).

$HELTF_{-244,244}$ =

{+1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, −1, +1, +1, −1, +1, −1, −1, −1,
+1, +1, −1, −1, −1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −1, −1, −1, −1, −1, +1, −1,
+1, +1, +1, −1, −1, +1, +1, +1, −1, −1, +1, +1, +1, +1, −1, +1, +1, −1, −1, +1, −1, +1, −1,
+1, −1, −1, +1, −1, +1, +1, +1, −1, −1, +1, +1, +1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1,
+1, −1, −1, −1, −1, −1, +1, −1, +1, +1, +1, −1, −1, +1, +1, +1, +1, +1, +1, +1, +1, −1, +1,
+1, −1, −1, +1, −1, +1, +1, +1, +1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1, −1, −1, −1, −1,
−1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, −1, +1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1,
−1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −1, −1, −1, −1, −1, +1, −1, +1, +1, +1, −1,
−1, +1, +1, +1, −1, −1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, −1, +1, +1, −1,
+1, −1, −1, −1, +1, +1, −1, −1, −1, +1, +1, +1, +1, −1, +1, +1, −1, −1, +1, −1, +1, +1, +1,
+1, +1, −1, +1, −1, −1, −1, +1, 0, 0, 0, 0, 0, −1, +1, +1, +1, +1, −1, +1, (28-40)
+1, −1, −1, +1, −1, +1, −1, +1, −1, −1, +1, −1, +1, +1, +1, −1, −1, +1, +1, +1, +1, +1, +1,
+1, −1, +1, +1, −1, −1, +1, −1, +1, +1, +1, +1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1, −1,
+1, +1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, −1, +1, +1, −1, +1, −1, −1, −1,
+1, +1, −1, −1, −1, +1, +1, +1, +1, −1, +1, +1, −1, −1, +1, −1, +1, +1, +1, +1, +1, −1, +1,
−1, −1, −1, +1, +1, −1, −1, −1, +1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, −1,
+1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1, −1, +1, −1, −1, −1, −1, +1, −1, −1, +1, +1, −1,
+1, −1, +1, −1, +1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1, −1, −1, −1, −1, −1, +1, −1, −1,
+1, +1, −1, +1, −1, −1, −1, −1, −1, +1, −1, +1, +1, +1, −1, −1, +1, +1, +1, −1, +1, −1, −1,
−1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, −1, +1, +1, −1, +1, −1, −1, −1, +1, +1, −1, −1,
−1, +1, +1, +1, +1, −1, +1, +1, −1, −1, +1, −1, +1, +1, +1, +1, +1, −1, +1, −1, −1, −1, +1,
+1, −1, −1, −1, −1}

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In an 80 MHz transmission, the 1x HE-LTF sequence transmitted on subcarriers [−500: 500] is given by Equation (28-41).

$HELTF_{-500,500}$ =

{−1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0,
0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0,
0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1,
0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −
1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0,
+1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0,
0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0,
0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1,
0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −
1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0,
+1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0,
0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0,
0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1,
0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −
1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0,
−1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0,
0, 0, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0,
0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0,
0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1,
0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0,
+1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0,
0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0,
0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1,
0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0,
+1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0,
0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0,
0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1,
0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0,
+1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0,
0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0,
0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1,
0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0,
+1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0,
0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, +1, 0,
0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1,
0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, +1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0, −1, 0, 0, 0,
+1, 0, 0, 0, +1} (28-41)

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In an 80 MHz transmission, the 2x HE-LTF sequence transmitted on subcarriers [–500: 500] is given by Equation (28-42).

$$
\begin{aligned}
&HELTF_{-500,500} = \\
&\{+1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, \\
&0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, \\
&0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, \\
&0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, \\
&0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, \\
&0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, \\
&0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, \\
&0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, \\
&0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, \\
&0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, \\
&0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, \\
&0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, \\
&0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, \\
&0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, \\
&0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, \\
&0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, \\
&0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, \\
&0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, 0, 0, 0, 0, 0, 0, \\
&+1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, \\
&-1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, \\
&+1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, \\
&+1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, \\
&+1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, \\
&+1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, \\
&+1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, \\
&+1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, \\
&-1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, \\
&+1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, \\
&-1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, \\
&+1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, \\
&-1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, \\
&-1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, \\
&-1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, \\
&-1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, \\
&-1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, \\
&+1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1\}
\end{aligned}
\tag{28-42}
$$

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In an 80 MHz transmission, the 4x HE-LTF sequence transmitted on subcarriers [–500: 500] is given by Equation (28-43).

$$
\begin{aligned}
&HELTF_{-500,500} = \\
&\{+1,+1,-1,+1,-1,+1,-1,-1,-1,+1,-1,-1,-1,+1,+1,-1,+1,+1,+1,+1,+1,-1,-\\
&1,+1,+1,+1,+1,-1,+1,-1,+1,-1,-1,+1,+1,-1,+1,+1,+1,-1,-1,+1,-1,-1,-1,\\
&-1,+1,+1,+1,-1,-1,-1,-1,-1,-1,-1,+1,+1,+1,+1,+1,+1,-1,+1,+1,+1,-1,+1,+1,\\
&-1,-1,-1,+1,-1,+1,-1,-1,+1,+1,-1,+1,-1,+1,+1,+1,+1,+1,-1,-1,+1,+1,+1,\\
&-1,+1,+1,-1,-1,-1,+1,-1,+1,+1,-1,+1,+1,-1,+1,-1,-1,+1,+1,+1,+1,-1,-1,\\
&+1,+1,+1,+1,+1,-1,+1,+1,-1,-1,-1,+1,-1,-1,-1,+1,-1,+1,-1,+1,+1,-1,+1,\\
&-1,+1,-1,+1,+1,+1,-1,+1,+1,+1,-1,-1,+1,-1,-1,-1,-1,-1,+1,+1,-1,-1,-1,\\
&-1,+1,-1,+1,-1,+1,+1,-1,-1,+1,-1,-1,-1,+1,+1,-1,+1,+1,+1,+1,-1,-1,-1,\\
&+1,+1,+1,+1,-1,+1,+1,+1,+1,+1,+1,+1,-1,+1,+1,+1,-1,+1,+1,-1,-1,-1,+1,\\
&-1,+1,-1,-1,+1,+1,-1,+1,-1,+1,+1,+1,+1,+1,-1,-1,+1,+1,+1,-1,+1,+1,-1,\\
&-1,-1,+1,-1,+1,+1,-1,+1,+1,-1,+1,-1,-1,+1,-1,+1,-1,+1,-1,+1,+1,+1,-1,\\
&+1,+1,+1,-1,-1,+1,-1,-1,-1,-1,-1,+1,+1,-1,-1,-1,-1,+1,-1,+1,-1,+1,+1,\\
&-1,-1,+1,-1,-1,-1,+1,+1,-1,+1,+1,+1,+1,-1,-1,-1,+1,+1,+1,+1,-1,+1,-1,\\
&-1,-1,-1,-1,-1,+1,-1,-1,-1,+1,-1,-1,+1,+1,+1,-1,+1,-1,+1,+1,-1,-1,+1,\\
&-1,+1,-1,-1,-1,-1,-1,+1,+1,-1,-1,-1,+1,-1,-1,+1,-1,+1,-1,+1,+1,-1,-1,\\
&-1,+1,-1,-1,-1,-1,-1,-1,+1,+1,-1,-1,-1,+1,-1,-1,+1,+1,+1,-1,+1,-1,+1,\\
&-1,+1,-1,-1,+1,-1,+1,+1,+1,-1,+1,-1,-1,+1,+1,-1,+1,-1,+1,+1,+1,-1,-1,\\
&+1,-1,-1,-1,+1,-1,-1,-1,-1,-1,-1,-1,+1,-1,+1,+1,-1,+1,+1,-1,+1,-1,-1,\\
&-1,+1,+1,-1,+1,+1,+1,-1,-1,+1,+1,+1,+1,+1,+1,-1,+1,-1,-1,-1,-1,+1,+1,-1,\\
&-1,-1,-1,-1,+1,-1,-1,+1,+1,+1,-1,+1,+1,+1,-1,+1,-1,+1,-1,-1,-1,-1,-1,\\
&+1,+1,+1,-1,-1,-1,-1,+1,-1,-1,+1,+1,+1,-1,+1,+1,-1,-1,+1,-1,+1,-1,+1,\\
&+1,+1,-1,+1,-1,-1,+1,+1,-1,+1,-1,+1,+1,+1,-1,-1,+1,-1,-1,-1,+1,-1,-1,\\
&-1,-1,-1,-1,-1,+1,-1,+1,+1,-1,+1,+1,-1,+1,-1,-1,-1,+1,+1,-1,+1,+1,+1,\\
&-1,-1,+1,+1,+1,+1,+1,-1,+1,+1,+1,+1,+1,-1,-1,+1,+1,+1,+1,+1,-1,+1,+1,\\
&-1,-1,-1,+1,-1,-1,-1,+1,-1,+1,-1,+1,+1,+1,+1,+1,-1,-1,-1,+1,+1,+1,+1,\\
&-1,+1,+1,-1,-1,-1,+1,-1,-1,+1,+1,-1,+1,-1,+1,-1,-1,-1,-1,-1,-1,+1,+1,\\
&-1,-1,-1,+1,-1,-1,+1,+1,+1,-1,+1,-1,-1,+1,-1,-1,+1,-1,+1,-1,+1,-1,+1,\\
&-1,-1,+1,+1,-1,+1,-1,+1,+1,+1,-1,-1,+1,-1,-1,-1,+1,-1,-1,-1,-1,-1,-1,\\
&-1,+1,-1,+1,+1,-1,+1,+1,-1,+1,-1,-1,-1,+1,+1,-1,+1,+1,+1,-1,-1,+1,+1,\\
&+1,+1,+1,-1,+1,-1,-1,-1,-1,+1,+1,-1,-1,-1,-1,-1,+1,-1,-1,+1,+1,+1,-1,\\
&+1,+1,+1,-1,+1,-1,+1,-1,-1,-1,-1,-1,+1,+1,+1,-1,-1,-1,-1,+1,-1,-1,+1,\\
&+1,+1,-1,+1,+1,-1,-1,+1,-1,+1,-1,+1\}
\end{aligned}
\qquad (28\text{-}43)
$$

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In a 160 MHz transmission using a 1x HE-LTF, the 1x HE-LTF sequence is given by Equation (28-44).

$$HELTF_{-1012,1012} = \{LTF_{80MHz_lower_1x}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, LTF_{80MHz_upper_1x}\} \quad (28\text{-}44)$$

where

$LTF_{80MHz_lower_1x} = \{LTF_{80MHz_left_1x}, 0, LTF_{80MHz_right_1x}\}$ shall be used in the lower 80 MHz frequency segment

$LTF_{80MHz_upper_1x} = \{LTF_{80MHz_left_1x}, 0, -LTF_{80MHz_right_1x}\}$ shall be used in the upper 80 MHz frequency segment

$LTF_{80MHz_left_1x}$ = {–1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0}

$LTF_{80MHz_right_1x}$ = {0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, –1, 0, 0, 0, +1, 0, 0, 0, +1}

In a 160 MHz transmission using a 2x HE-LTF, the 2x HE-LTF sequence is given by Equation (28-45).

$$HELTF_{-1012,1012} = \{LTF_{80MHz_lower_2x}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, LTF_{80MHz_upper_2x}\} \quad (28\text{-}45)$$

where

$LTF_{80MHz_lower_2x} = \{LTF_{80MHz_part1_2x}, LTF_{80MHz_part2_2x}, LTF_{80MHz_part3_2x}, LTF_{80MHz_part4_2x}, LTF_{80MHz_part5_2x}\}$ shall be used in the lower 80 MHz frequency segment

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$LTF_{80\text{MHz_upper_2x}} = \{LTF_{80\text{MHz_part1_2x}}, -LTF_{80\text{MHz_part2_2x}}, LTF_{80\text{MHz_part3_2x}}, LTF_{80\text{MHz_part4_2x}}, -LTF_{80\text{MHz_part5_2x}}\}$ shall be used in the upper 80 MHz frequency segment

$LTF_{80\text{MHz_part1_2x}}$ = {+1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0}

$LTF_{80\text{MHz_part2_2x}}$ = {+1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0}

$LTF_{80\text{MHz_part3_2x}}$ = {+1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, 0, 0, 0, 0, 0, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1}

$LTF_{80\text{MHz_part4_2x}}$ = {0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1}

$LTF_{80\text{MHz_part5_2x}}$ = {0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, –1, 0, –1, 0, +1, 0, –1, 0, –1, 0, –1, 0, +1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1, 0, +1, 0, –1, 0, +1, 0, +1}

In a 160 MHz transmission using a 4x HE-LTF, the 4x HE-LTF sequence is given by Equation (28-46).

$$HELTF_{-1012,1012} = \{LTF_{80\text{MHz_lower_4x}}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, LTF_{80\text{MHz_upper_4x}}\} \quad (28\text{-}46)$$

where

$LTF_{80\text{MHz_lower_4x}} = \{LTF_{80\text{MHz_left_4x}}, 0, LTF_{80\text{MHz_right_4x}}\}$ shall be used in the lower 80 MHz frequency segment

$LTF_{80\text{MHz_upper_4x}} = \{LTF_{80\text{MHz_left_4x}}, 0, -LTF_{80\text{MHz_right_4x}}\}$ shall be used in the upper 80 MHz frequency segment

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$LTF_{80MHz\_left\_4x}$ = {+1, +1, −1, +1, −1, +1, −1, −1, −1, +1, −1, −1, −1, +1, +1, −1, +1, +1, +1, +1, +1, −1,
−1, +1, +1, +1, +1, −1, +1, −1, +1, −1, −1, +1, +1, −1, +1, +1, +1, −1, −1, +1, −1, −1, −1, −1,
+1, +1, +1, −1, −1, −1, −1, −1, −1, +1, +1, +1, +1, +1, +1, −1, +1, +1, +1, −1, +1, +1, −1, −1, −
1, +1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, +1, +1, +1, +1, −1, −1, +1, +1, +1, −1, +1, +1, −1,
−1, −1, +1, −1, +1, +1, −1, +1, +1, −1, +1, −1, −1, +1, +1, +1, +1, −1, −1, +1, +1, +1, +1, +1, −
1, +1, +1, −1, −1, −1, +1, −1, −1, −1, +1, −1, +1, −1, +1, +1, −1, +1, −1, +1, −1, +1, +1, +1, −1,
+1, +1, +1, −1, −1, +1, −1, −1, −1, −1, −1, +1, +1, −1, −1, −1, −1, +1, −1, +1, −1, +1, +1, −1, −
1, +1, −1, −1, −1, +1, +1, −1, +1, +1, +1, +1, −1, −1, −1, +1, +1, +1, +1, −1, +1, +1, +1, +1, +1,
+1, +1, −1, +1, +1, +1, −1, +1, +1, −1, −1, −1, +1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, +1,
+1, +1, +1, −1, −1, +1, +1, +1, −1, +1, +1, −1, −1, −1, +1, −1, +1, +1, −1, +1, +1, −1, +1, −1, −
1, +1, −1, +1, −1, +1, −1, +1, +1, +1, −1, +1, +1, +1, −1, −1, +1, −1, −1, −1, −1, −1, +1, +1, −1,
−1, −1, −1, +1, −1, +1, −1, +1, +1, −1, −1, +1, −1, −1, −1, +1, +1, −1, +1, +1, +1, +1, −1, −1, −
1, +1, +1, +1, +1, −1, +1, −1, −1, −1, −1, −1, −1, +1, −1, −1, −1, +1, −1, −1, +1, +1, +1, −1, +1,
−1, +1, +1, −1, −1, +1, −1, +1, −1, −1, −1, −1, −1, +1, +1, −1, −1, −1, +1, −1, −1, +1, +1, +1, −
1, +1, −1, −1, +1, −1, −1, +1, −1, +1, +1, +1, +1, +1, +1, −1, −1, +1, +1, +1, +1, +1, −1, +1, +1,
−1, −1, −1, +1, −1, −1, −1, +1, −1, +1, −1, +1, +1, −1, +1, −1, +1, −1, +1, +1, +1, −1, +1, +1,
+1, −1, −1, +1, −1, −1, −1, −1, −1, +1, +1, −1, −1, −1, −1, +1, −1, +1, −1, +1, +1, −1, −1, +1, −
1, −1, −1, +1, +1, −1, +1, +1, +1, +1, −1, −1, −1, +1, +1, +1, +1, −1, −1, +1, +1, +1, +1, +1, +1,
−1, +1, +1, +1, −1, +1, +1, −1, −1, −1, +1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, +1, +1, +1,
+1, −1, −1, +1, +1, +1, −1, +1, +1, −1, −1, −1, +1, −1, +1, +1, −1, +1, +1, −1, +1, −1, −1, −1,
+1, −1, +1, −1, −1, −1, −1, +1, +1, +1, −1, −1, +1, 0, 0}

$LTF_{80MHz\_right\_4x}$ = {0, 0, +1, −1, −1, −1, −1, −1, −1, +1, −1, +1, +1, −1, −1, +1, +1, −1, +1, −1, +1, +1, −
1, −1, +1, −1, +1, −1, −1, −1, +1, +1, −1, +1, +1, +1, −1, +1, +1, +1, +1, +1, +1, +1, −1, +1, −1,
−1, +1, −1, −1, +1, −1, +1, +1, +1, −1, −1, +1, −1, −1, −1, +1, +1, −1, −1, −1, −1, −1, +1, −1, −
1, −1, −1, −1, +1, +1, −1, −1, −1, −1, −1, +1, −1, −1, +1, +1, +1, −1, +1, +1, +1, −1, +1, −1, +1,
−1, −1, −1, −1, −1, +1, +1, +1, −1, −1, −1, −1, +1, −1, −1, +1, +1, +1, −1, +1, +1, −1, −1, +1, −
1, +1, −1, −1, −1, −1, −1, −1, −1, +1, +1, −1, −1, −1, +1, −1, −1, +1, +1, +1, −1, +1, −1, −1, +1,
−1, −1, +1, −1, +1, +1, +1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, +1, +1, −1, −1, +1, −1, −1, −
1, +1, −1, −1, −1, −1, −1, −1, −1, +1, −1, +1, +1, −1, +1, +1, −1, +1, −1, −1, −1, +1, +1, −1, +1,
+1, +1, −1, −1, +1, +1, +1, +1, +1, −1, +1, −1, −1, −1, −1, +1, +1, −1, −1, −1, −1, −1, +1, −1, −
1, +1, +1, +1, −1, +1, +1, +1, −1, +1, −1, +1, −1, −1, −1, −1, −1, +1, +1, +1, −1, −1, −1, −1, +1,
−1, −1, +1, +1, +1, −1, +1, +1, −1, −1, +1, −1, +1, −1, +1, +1, +1, −1, +1, −1, −1, +1, +1, −1,
+1, −1, +1, +1, +1, −1, −1, +1, −1, −1, −1, +1, −1, −1, −1, −1, −1, −1, −1, +1, −1, +1, +1, −1,
+1, +1, −1, +1, −1, −1, −1, +1, +1, −1, +1, +1, +1, −1, −1, +1, +1, +1, +1, +1, −1, +1, +1, +1,
+1, +1, −1, −1, +1, +1, +1, +1, +1, −1, +1, +1, −1, −1, −1, +1, −1, −1, −1, +1, −1, +1, −1, +1,
+1, +1, +1, +1, −1, −1, −1, +1, +1, +1, +1, −1, +1, +1, −1, −1, −1, +1, −1, −1, +1, +1, −1, +1, −
1, +1, −1, −1, −1, −1, −1, −1, +1, +1, −1, −1, −1, +1, −1, −1, +1, +1, +1, −1, +1, −1, −1, +1, −1,
−1, +1, −1, +1, −1, +1, −1, +1, −1, −1, +1, +1, −1, +1, −1, +1, +1, +1, −1, −1, +1, −1, −1, −1,
+1, −1, −1, −1, −1, −1, −1, −1, +1, −1, +1, +1, −1, +1, +1, −1, +1, −1, −1, −1, +1, +1, −1, +1,
+1, +1, −1, −1, +1, +1, +1, +1, +1, −1, +1, −1, −1, −1, −1, +1, +1, −1, −1, −1, −1, −1, +1, −1, −
1, +1, +1, +1, −1, +1, +1, +1, −1, +1, −1, +1, −1, −1, −1, −1, −1, +1, +1, +1, −1, −1, −1, −1, +1,
−1, −1, +1, +1, +1, −1, +1, +1, −1, −1, +1, −1, +1, −1, +1, −1, −1, +1, −1, +1, +1, −1, −1}

For an 80+80 MHz transmission using a 1x HE-LTF, the lower 80 MHz frequency segment shall use the 80 MHz 1x HE-LTF sequence, $HELTF_{-500,500} = LTF_{80MHz\_lower\_1x}$, and the upper 80 MHz frequency segment shall use the 80 MHz 1x HE-LTF sequence, $HELTF_{-500,500} = LTF_{80MHz\_upper\_1x}$.

For an 80+80 MHz transmission using a 2x HE-LTF, the lower 80 MHz frequency segment shall use the 80 MHz 2x HE-LTF sequence, $HELTF_{-500,500} = LTF_{80MHz\_lower\_2x}$, and the upper 80 MHz frequency segment shall use the 80 MHz 2x HE-LTF sequence, $HELTF_{-500,500} = LTF_{80MHz\_upper\_2x}$.

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For an 80+80 MHz transmission using a 4x HE-LTF, the lower 80 MHz frequency segment shall use the 80 MHz 4x HE-LTF sequence, $HELTF_{-500,500} = LTF_{80\text{MHz\_lower\_4x}}$, and the upper 80 MHz frequency segment shall use the 80 MHz 4x HE-LTF sequence, $HELTF_{-500,500} = LTF_{80\text{MHz\_upper\_4x}}$.

For an OFDMA transmission, the values of HE-LTF sequence (defined in Equation (28-35) to Equation (28-51)) are set to zero if they are assigned to subcarriers within RUs that are not allocated to any user (see 28.3.9 (Mathematical description of signals)).

In an UL MU-MIMO transmission using neither HE single stream pilot HE LTF mode in HE-LTF nor 1x HE-LTF, the HE-LTF sequence per frequency segment is generated by masking the non-zero elements in the common HE-LTF sequence repeatedly with a distinct orthogonal code as defined by Equation (28-47).

$$HELTF^{\text{Mask}}_{k,u,m} = HELTF_k \cdot \left[P_{8\times 8}\right]_{M_{r,u}+m,\left(\left(\left\lceil \frac{k}{N_{\text{HE-LTF-Mode}}} \right\rceil - 1\right) \bmod 8\right)+1} \tag{28-47}$$

Where $HELTF_k$ is the value of the common HE-LTF sequence on subcarrier k generated by one of the equations from Equation (28-35) to Equation (28-46) depending on the bandwidth and the HE-LTF mode (excluding the 1x HE-LTF which shall not be masked). $\left[P_{8\times 8}\right]$ is defined in Equation (21-46). $M_{r,u} + m$ is the row of the $\left[P_{8\times 8}\right]$ corresponding to the spatial time stream of user u in the r-th RU. Depending on the HE-LTF modes, $N_{\text{HE-LTF-Mode}}$ is defined in Equation (28-48).

$$N_{\text{HE-LTF-Mode}} = \begin{cases} 2, \text{ for 2x HE-LTF} \\ 1, \text{ for 4x HE-LTF} \end{cases} \tag{28-48}$$

In the HE TB NDP feedback PPDU, neither HE single stream pilot HE LTF mode nor HE masked HE LTF sequence mode is applied to the HE-LTF sequence. Only 4x HE-LTF shall be used in the HE TB NDP feedback PPDU. The 4x HE-LTF sequence is generated by Equation (28-49).

$$HELTF^{\text{TB\_NDP}}_{k,u} = \begin{cases} HELTF_k, \text{ if } k \in K_{\text{tone\_NDP}_u} \\ 0, \text{ otherwise} \end{cases} \tag{28-49}$$

where

$HELTF_k$ is the value of the common HE-LTF sequence on subcarrier k generated by one of the 4x HE-LTF equations (Equation (28-37), Equation (28-40), Equation (28-43), Equation (28-46)) according to the channel bandwidth

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$K_{\text{tone\_NDP}u}$ is the set of subcarrier indices for user u and is defined in 28-28 (HE-LTF tone mapping for the HE TB NDP feedback PPDU) according to the RU_TONE_SET_INDEX and FEED-

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BACK_STATUS.

Table 28-28—HE-LTF tone mapping for the HE TB NDP feedback PPDU

	80 MHz		40 MHz		20 MHz	
RU_TONE_SET_INDEX	**$K_{tone\_NDP\mu}$ if FEEDBACK_STATUS is 1**	**$K_{tone\_NDP\mu}$ if FEEDBACK_STATUS is 0**	**$K_{tone\_NDP\mu}$ if FEEDBACK_STATUS is 1**	**$K_{tone\_NDP\mu}$ if FEEDBACK_STATUS is 0**	**$K_{tone\_NDP\mu}$ if FEEDBACK_STATUS is 1**	**$K_{tone\_NDP\mu}$ if FEEDBACK_STATUS is 0**
1	Use 20 MHz FEEDBACK_STATUS = 1 Subcarrier Indices – 384	Use 20 MHz FEEDBACK_STATUS = 0 Subcarrier Indices – 384	Use 20 MHz FEEDBACK_STATUS = 1 Subcarrier Indices – 128	Use 20 MHz FEEDBACK_STATUS = 0 Subcarrier Indices – 128	–113, –77, –41, 6, 42, 78	–112, –76, –40, 7, 43, 79
2					–111, –75, –39, 8, 44, 80	–110, –74, –38, 9, 45, 81
3					–109, –73, –37, 10, 46, 82	–108, –72, –36, 11, 47, 83
4					–107, –71, –35, 12, 48, 84	–106, –70, –34, 13, 49, 85
5					–105, –69, –33, 14, 50, 86	–104, –68, –32, 15, 51, 87
6					–103, –67, –31, 16, 52, 88	–102, –66, –30, 17, 53, 89
7					–101, –65, –29, 18, 54, 90	–100, –64, –28, 19, 55, 91
8					–99, –63, –27, 20, 56, 92	–98, –62, –26, 21, 57, 93
9					–97, –61, –25, 22, 58, 94	–96, –60, –24, 23, 59, 95
10					–95, –59, –23, 24, 60, 96	–94, –58, –22, 25, 61, 97
11					–93, –57, –21, 26, 62, 98	–92, –56, –20, 27, 63, 99
12					–91, –55, –19, 28, 64, 100	–90, –54, –18, 29, 65, 101
13					–89, –53, –17, 30, 66, 102	–88, –52, –16, 31, 67, 103
14					–87, –51, –15, 32, 68, 104	–86, –50, –14, 33, 69, 105
15					–85, –49, –13, 34, 70, 106	–84, –48, –12, 35, 71, 107
16					–83, –47, –11, 36, 72, 108	–82, –46, –10, 37, 73, 109
17					–81, –45, –9, 38, 74, 110	–80, –44, –8, 39, 75, 111
18					–79, –43, –7, 40, 76, 112	–78, –42, –6, 41, 77, 113

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Table 28-28—HE-LTF tone mapping for the HE TB NDP feedback PPDU *(continued)*

	80 MHz		40 MHz		20 MHz	
RU_TONE_SET_INDEX	**$K_{tone\_NDP\mu}$ if FEEDBACK_STATUS is 1**	**$K_{tone\_NDP\mu}$ if FEEDBACK_STATUS is 0**	**$K_{tone\_NDP\mu}$ if FEEDBACK_STATUS is 1**	**$K_{tone\_NDP\mu}$ if FEEDBACK_STATUS is 0**	**$K_{tone\_NDP\mu}$ if FEEDBACK_STATUS is 1**	**$K_{tone\_NDP\mu}$ if FEEDBACK_STATUS is 0**
19-36	Use 20 MHz FEEDBACK_STATUS = 1 Subcarrier Indices – 128	Use 20 MHz FEEDBACK_STATUS = 0 Subcarrier Indices – 128	Use 20 MHz FEEDBACK_STATUS = 1 Subcarrier Indices + 128	Use 20 MHz FEEDBACK_STATUS = 0 Subcarrier Indices + 128		
37-54	Use 20 MHz FEEDBACK_STATUS = 1 Subcarrier Indices + 128	Use 20 MHz FEEDBACK_STATUS = 0 Subcarrier Indices + 128				
55-72	Use 20 MHz FEEDBACK_STATUS = 1 Subcarrier Indices + 384	Use 20 MHz FEEDBACK_STATUS = 0 Subcarrier Indices + 384				
The RU_TONE_SET_INDEX for 80+80 MHz and 160 MHz shall use the 80 MHz RU_TONE_SET_INDEX definition for the lower and upper 80 MHz. The RU_TONE_SET_INDEX values 1-72 are mapped to the lower 80 MHz and the RU_TONE_SET_INDEX values 73-144 are mapped to the upper 80 MHz.						

The generation of the time domain HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU, HE ER SU PPDU, and HE TB PPDU is shown in Figure 28-31 (Generation of HE-LTF symbols per

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frequency segment in an HE SU PPDU, HE MU PPDU, HE ER SU PPDU and HE TB PPDU) where $A^{k}_{\text{HE-LTF}}$ is given by Equation (28-50).

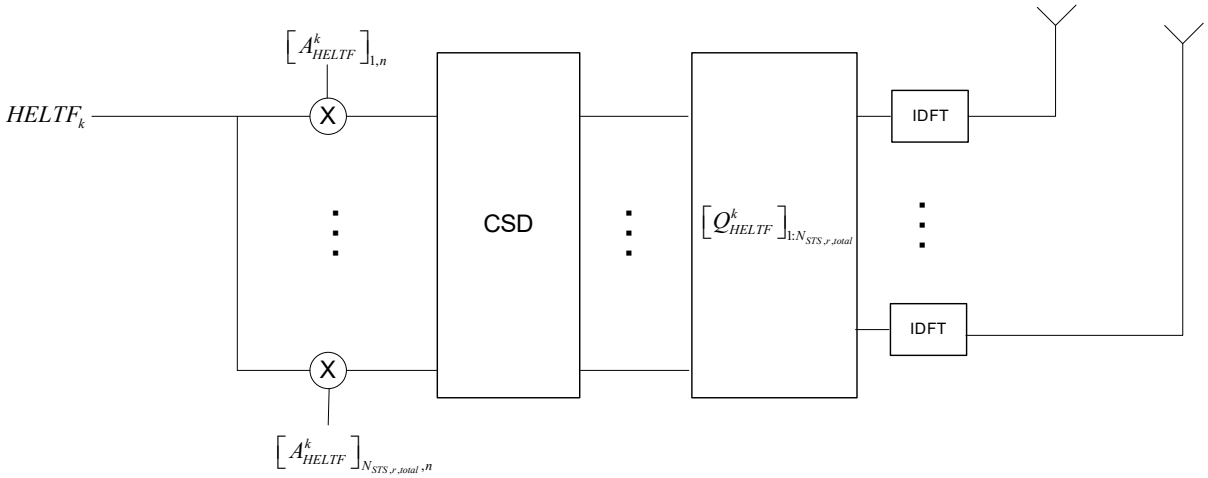


Figure 28-31—Generation of HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU, HE ER SU PPDU and HE TB PPDU

The generation of time domain symbol of 1x HE-LTF is equivalent to modulating every 4 tones in an OFDM symbol of 12.8 μs excluding GI, and then only transmit the first ¼ of the OFDM symbol in the time domain, as shown in Figure 28-32 (Generation of 1x HE-LTF symbols per frequency segment).

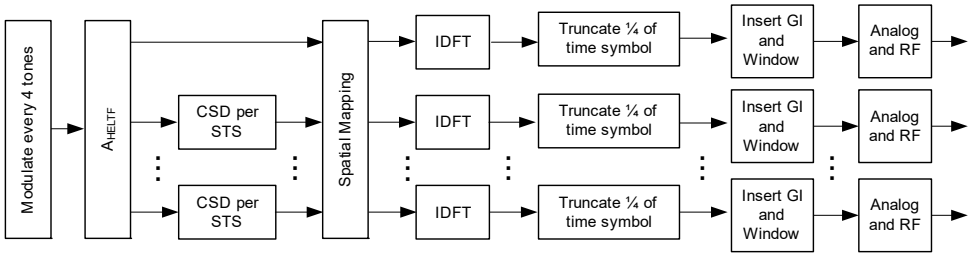


Figure 28-32—Generation of 1x HE-LTF symbols per frequency segment

The generation of time domain symbol of 2x HE-LTF is equivalent to modulating every other tone in an OFDM symbol of 12.8 μs excluding GI, and then only transmit the first half of the OFDM symbol in time domain, as shown in Figure 28-33 (Generation of 2x HE-LTF symbols per frequency segment).

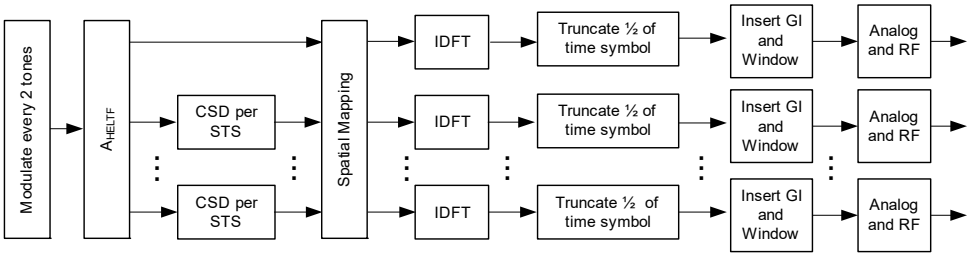


Figure 28-33—Generation of 2x HE-LTF symbols per frequency segment

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$A^{k}_{\text{HE-LTF}}$ is given by Equation (28-50).

$$A^{k}_{\text{HE-LTF}} = \begin{cases} R_{\text{HE-LTF}}, \text{ if } k \in K_{\text{Pilot}} \text{ and HE single stream pilot HE LTF mode is used} \\ P_{\text{HE-LTF}}, \text{ otherwise} \end{cases} \quad (28\text{-}50)$$

where

K_{Pilot} is the set of subcarrier indices for the pilot subcarriers as defined in 28.3.3.4 (Pilot subcarriers).

$R_{\text{HE-LTF}}$is a $N_{\text{HE-LTF}} \times N_{\text{HE-LTF}}$ matrix whose elements are defined in Equation (28-51).

$$\left[R_{\text{HE-LTF}}\right]_{m,n} = \left[P_{\text{HE-LTF}}\right]_{1,n},\ 1 \le m, n \le N_{\text{HE-LTF}} \quad (28\text{-}51)$$

$P_{\text{HE-LTF}}$is defined in Equation (28-52).

$$P_{\text{HE-LTF}} = \begin{cases} P_{4\times 4}, N_{\text{HE-LTF}} \le 4 \\ P_{6\times 6}, N_{\text{HE-LTF}} = 5, 6 \\ P_{8\times 8}, N_{\text{HE-LTF}} = 7, 8 \end{cases} \quad (28\text{-}52)$$

where $P_{4\times 4}$ is defined in Equation (19-27), $P_{6\times 6}$ is defined in Equation (21-44), and $P_{8\times 8}$ is defined in Equation (22-45).

When the 1x HE-LTF is used for non-OFDMA UL MU-MIMO, neither HE masked HE LTF sequence mode nor HE single stream pilot HE LTF mode are used.

In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, the time domain representation of the waveform transmitted on frequency segment i_{Seg} and transmit chain i_{TX} shall be as described by Equation (28-53).

$$r^{(i_{Seg}, i_{TX})}_{\text{HE-LTF}}(t) = \frac{1}{\sqrt{\sum_{r=0}^{N_{RU}-1} \alpha_r^2 |K_r|}} \sum_{n=0}^{N_{\text{HE-LTF}}-1} w_{T_{\text{HE-LTF}}}(t - nT_{\text{HE-LTF}}) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r \sqrt{|K_r|}}{\sqrt{N_{STS,r,total} \left|K_r^{\text{HE-LTF}}\right|}}$$
$$\sum_{k \in K_r} \eta_{\text{HE-LTF},k} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left(\begin{array}{l} \left[Q_k^{(i_{Seg})}\right]_{i_{TX},(M_{r,u}+m)} \left[A^{k}_{\text{HE-LTF}}\right]_{(M_{r,u}+m),(n+1)} HELTF''_{k,u,m} \\ \cdot \exp(j2\pi k \Delta_{F,\text{HE}}(t - nT_{\text{HE-LTF}} - T_{GI,\text{HE-LTF}} - T_{CS,\text{HE}}(M_{r,u}+m))) \end{array} \right) \quad (28\text{-}53)$$

In an HE TB PPDU, the time domain representation of the waveform of user u in the r-th RU, transmitted on frequency segment i_{Seg} and transmit chain i_{TX} shall be as described by Equation (28-54).

$$r^{(i_{Seg}, i_{TX})}_{\text{HE-LTF}}(t) = \frac{1}{\sqrt{N_{STS,r,u} \left|K_r^{\text{HE-LTF}}\right|}} \sum_{n=0}^{N_{\text{HE-LTF}}-1} w_{T_{\text{HE-LTF}}}(t - nT_{\text{HE-LTF}})$$
$$\sum_{k \in K_r} \sum_{m=1}^{N_{STS,r,u}} \left(\begin{array}{l} \left[Q_{k,u}^{(i_{Seg})}\right]_{i_{TX},m} \left[A^{k}_{\text{HE-LTF}}\right]_{(M_{r,u}+m),(n+1)} HELTF''_{k,u,m} \\ \cdot \exp(j2\pi k \Delta_{F,\text{HE}}(t - nT_{\text{HE-LTF}} - T_{GI,\text{HE-LTF}} - T_{CS,\text{HE}}(M_{r,u}+m))) \end{array} \right) \quad (28\text{-}54)$$

where

$HELTF''_{k,u,m}$ is the HE-LTF sequence applied on subcarrier k for spatial stream m of user u.

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$$HELTF''_{k,u,m} = \begin{cases} HELTF^{\text{Mask}}_{k,u,m}, \text{ if HE masked HE-LTF sequence mode is used} \\ HELTF^{\text{TB\_NDP}}_{k,u}, \text{ if HE TB NDP feedback is used} \\ HELTF_k, \text{ otherwise} \end{cases}$$

α_r is defined in 28.3.9 (Mathematical description of signals).

$\eta_{\text{HE-LTF},k}$ is an HE PPDU format dependent scaling factor, defined by

$$\eta_{\text{HE-LTF},k} = \begin{cases} \sqrt{2}, \text{ for an HE ER SU PPDU} \\ 1, \text{ otherwise} \end{cases}$$

$N^{\text{Tone}}_{\text{HE-LTF}}$ is defined in Table 28-16 (Number of modulated subcarriers and guard interval duration values for HE PPDU fields)

$T_{CS,\text{HE}}(M_{r,u}+m)$ represents the cyclic shift for space-time stream $M_{r,u}+m$ as defined in 28.3.10.2.2 (Cyclic shift for HE modulated fields)

$Q_k^{(i_{Seg})}$ is defined in 28.3.9 (Mathematical description of signals)

$Q_{k,u}^{(i_{Seg})}$ is defined in 28.3.9 (Mathematical description of signals)

$A^k_{\text{HE-LTF}}$ is defined in Equation (28-50)

K_r is the set of subcarrier indices for the tones in the r-th RU as defined in 28.3.9 (Mathematical description of signals)

28.3.11 Data field

28.3.11.1 General

The number of OFDM symbols in the Data field is determined by the Length field in L-SIG (see Equation (28-11)), the preamble duration and the settings of the GI+LTF Size, Pre-FEC Padding Factor and PE Disambiguity fields in the HE-SIG-A field (see 28.3.10.7 (HE-SIG-A)). Data symbols in an HE PPDU shall use a DFT period of 12.8 μs and subcarrier spacing of 78.125 kHz. Data symbols in an HE PPDU shall support guard interval durations of 0.8 μs, 1.6 μs and 3.2 μs. HE PPDUs shall have single stream pilots in the Data field. In UL MU-MIMO transmissions, all streams use the same pilot sequence.

When BCC encoding is used, the Data field shall consist of the SERVICE field, the PSDU, the pre-FEC PHY padding bits, the tail bits, the post-FEC padding bits and the packet extension. When LDPC encoding is used, the Data field shall consist of the SERVICE field, the PSDU, the pre-FEC PHY padding bits, the post-FEC padding bits and the packet extension. No tail bits are present when LDPC encoding is used.

The Data field of the HE PPDU contains data for one or more users.

28.3.11.2 Pre-FEC padding process

A two-step padding process is applied an HE PPDU. A pre-FEC padding process including both pre-FEC MAC and pre-FEC PHY padding is applied before conducting FEC coding, and a post-FEC PHY padding process is applied on the FEC encoded bits.

The pre-FEC padding may pad toward 4 possible boundaries in the last one (in the case of non-STBC), or two (in the case of STBC) OFDM symbols of an HE PPDU, the 4 possible boundaries partition the FEC output bit stream of the last OFDM symbol(s) into 4 symbol segments. The 4 possible boundaries are represented by a pre-FEC padding factor parameter.

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Figure 28-34 (HE PPDU padding process in the last OFDM symbol (non-STBC) when a = 1) illustrates these 4 possible symbol segments in the last OFDM symbol of a non-STBC case, and the general padding process assuming the desired pre-FEC padding boundary, pre-FEC padding factor, is 1. In the case of STBC, the FEC output bits and post-FEC padding bits are modulated into the last two OFDM symbols by STBC encoding, each with the same number of effective symbol segments.

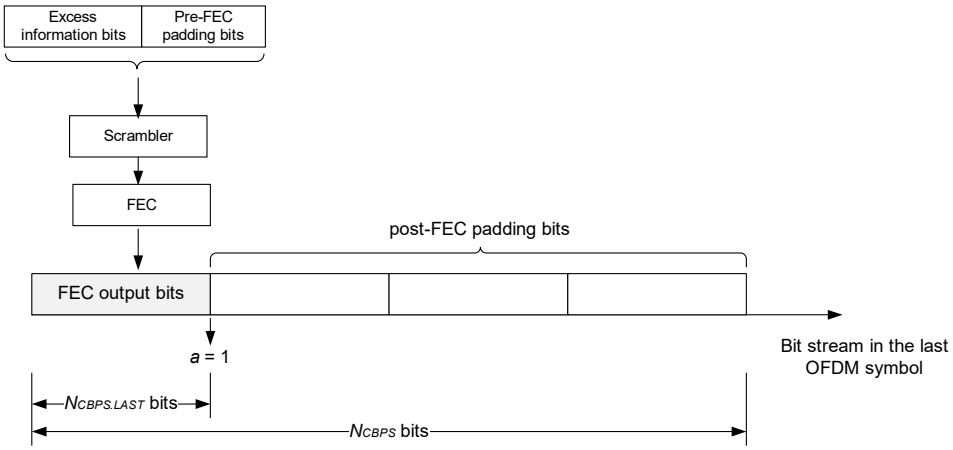


Figure 28-34—HE PPDU padding process in the last OFDM symbol (non-STBC) when *a* = 1

The pre-FEC padding process is described in this subclause, and the encoding and post-FEC padding process are described in 28.3.11.5 (Coding). While this subclause describes the pre-FEC padding processing of an SU transmission, its extension to MU transmission is described in 28.3.11.5.4 (Encoding process for an HE MU PPDU).

In an HE SU PPDU transmission, the transmitter first computes the number of bits left in the last OFDM symbol(s) based on Equation (28-55).

$$N_{Excess} = mod(8 \cdot \text{APEP\_LENGTH} + N_{Tail} + N_{service}, m_{STBC} \cdot N_{DBPS}) \quad (28\text{-}55)$$

where

m_{STBC} is 2 when STBC is used, and 1 otherwise

APEP_LENGTH is the TXVECTOR parameter APEP_LENGTH

Based on N_{Excess}, compute the initial number of symbol segments in the last OFDM symbol(s), pre-FEC padding factor value or a_{init}, as shown in Equation (28-56).

$$a_{init} = \begin{cases} 4, & \text{if } N_{Excess} = 0 \\ \min\left(\left\lceil \dfrac{N_{Excess}}{m_{STBC} \cdot N_{DBPS,SHORT}} \right\rceil, 4\right), & \text{otherwise} \end{cases} \quad (28\text{-}56)$$

where

$N_{DBPS,SHORT} = N_{CBPS,SHORT} \cdot R$, in which R is the coding rate, and

$N_{CBPS,SHORT} = N_{SD,SHORT} \cdot N_{SS} \cdot N_{BPSCS}$;

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The parameter $N_{SD,short}$ values for different RU sizes are as shown in Table 28-29 (NSD,short values).

Table 28-29—$N_{SD,short}$ values

RU Size	$N_{SD,short}$	
	DCM = 0	DCM = 1
26-tone	6	2
52-tone	12	6
106-tone	24	12
242-tone	60	30
484-tone	120	60
996-tone	240	120
2×996-tone	492	246

Given the a_{init} values, the initial number of data bits per symbol and the initial number of coded bits per symbol in the last OFDM symbol(s) are defined in Equation (28-57).

$$N_{DBPS,LAST,init} = \begin{cases} a_{init} N_{DBPS,SHORT}, \text{ if } a_{init} < 4 \\ N_{DBPS}, \text{ if } a_{init} = 4 \end{cases}$$
$$N_{CBPS,LAST,init} = \begin{cases} a_{init} N_{CBPS,SHORT}, \text{ if } a_{init} < 4 \\ N_{CBPS}, \text{ if } a_{init} = 4 \end{cases} \quad (28\text{-}57)$$

For an HE SU PPDU, the number of pre-FEC pad bits is calculated using Equation (28-58).

$$N_{PAD,\text{Pre-FEC}} = (N_{SYM.init} - m_{STBC}) N_{DBPS} + m_{STBC} N_{DBPS,LAST,init} - 8 \cdot \text{APEP\_LENGTH} - N_{Tail} - N_{service} \quad (28\text{-}58)$$

where $N_{SYM,init}$ is defined as in Equation (28-60) for BCC encoding, and Equation (28-65) for LDPC encoding.

Among the pre-FEC padding bits, the MAC delivers a PSDU that fills the available octets in the Data field of the HE PPDU (see A-MPDU padding for HE PPDUs in 27.10.2 (A-MPDU padding for an HE SU PPDU, HE ER SU PPDU and HE MU PPDU) and 27.10.3 (A-MPDU padding for an HE TB PPDU)), toward the desired pre-FEC padding boundary, represented by a_{init} value, in the last OFDM symbol(s). The number of pre-FEC pad bits added by MAC will always be a multiple of eight. The PHY then determines the number of remaining pad bits to add and appends them to the PSDU. The number of pre-FEC pad bits added by PHY will always be 0 to 7. The procedure is defined in Equation (28-59).

$$N_{PAD,\text{Pre-FEC,MAC}} = \left\lfloor \frac{N_{PAD,\text{Pre-FEC}}}{8} \right\rfloor \cdot 8$$
$$N_{PAD,\text{Pre-FEC,PHY}} = N_{PAD,\text{Pre-FEC}} \bmod 8 \quad (28\text{-}59)$$

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NOTE—$N_{PAD,\text{Pre-FEC,MAC}}$ is PSDU_LENGTH – APEP_LENGTH, where PSDU_LENGTH is computed using Equation (28-128). The corresponding A-MPDU padding process is defined in 27.10.2 (A-MPDU padding for an HE SU PPDU, HE ER SU PPDU and HE MU PPDU).

28.3.11.3 SERVICE field

The SERVICE field of HE PPDU is shown in Table 28-30 (SERVICE field).

Table 28-30—SERVICE field

Bits	Field	Description
B0-B6	Scrambler Initialization	Set to 0
B7-B15	Reserved	Set to 0

28.3.11.4 Scrambler

The SERVICE field, PSDU, and pre-FEC PHY padding of the Data field shall be scrambled by the scrambler defined in 17.3.5.5 (PHY DATA scrambler and descrambler). The Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) TXVECTOR parameters CH_BANDWIDTH_IN_NON_HT and DYN_BANDWIDTH_IN_NON_HT are not present and therefore the initial state of the scrambler is set to a nonzero pseudorandom seed. A different nonzero pseudorandom seed may be used for each user in an HE MU PPDU.

28.3.11.5 Coding

The Data field shall be encoded using either the binary convolutional code (BCC) defined in 28.3.11.5.1 (Binary convolutional coding and puncturing) or the low density parity check (LDPC) code defined in 28.3.11.5.2 (LDPC coding). The coding type is selected by the Coding field in HE-SIG-A in an HE SU PPDU or an HE ER SU PPDU, or the Coding field in HE-SIG-B per-user subfield(s) in an HE MU PPDU, or the Coding Type subfield in User Info field in a Trigger frame, as defined in 28.3.10.7 (HE-SIG-A), 28.3.10.8 (HE-SIG-B) and 9.3.1.23 (Trigger frame format), respectively.

When conducting BCC FEC encoding for an HE PPDU, the number of encoders is always 1.

LDPC is the only FEC coding scheme in the HE PPDU Data field for a 484-, 996-, and 2×996-tone RU. LDPC is the only FEC coding scheme in the HE PPDU Data field for HE-MCSs 10 and 11 in a 242- 484-, 996- and 2×996-tone RU. Support of BCC code is limited to less than or equal to four spatial streams and MCS0 to MCS9 (per user in case of MU-MIMO), and is mandatory (for both transmit and receive) for RU sizes less than or equal to a 242-tone RU. Support of LDPC code (for both transmit and receive) is mandatory for HE STAs declaring support for at least one of HE 40/80/160/80+80 SU PPDU bandwidths, for HE STAs declaring support for more than 4 spatial streams, or for HE STAs declaring support for HE-MCSs 10 and 11, according to HE capabilities field as defined in 9.4.2.237 (HE Capabilities element). Otherwise, support of LDPC code for either transmit or receive is optional.

28.3.11.5.1 Binary convolutional coding and puncturing

The information bits and pre-FEC padding bits of user *u* are encoded by a rate R = ½ convolutional encoder defined in 17.3.5.6 (Convolutional encoder). After encoding, the encoded data is punctured by the method defined in 17.3.5.6 (Convolutional encoder) (except for rate 5/6), to achieve the rate selected by the modulation and coding scheme. In the case that rate 5/6 coding is selected, the puncturing scheme will be the same as described in 21.3.10.5.3 (Binary convolutional coding and puncturing).

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The initial number of OFDM symbols in the Data field with BCC encoding in an HE SU PPDU or HE ER SU PPDU is calculated using Equation (28-60).

$$N_{SYM,\,init} = m_{STBC} \cdot \left\lceil \frac{8 \cdot \text{APEP\_LENGTH} + N_{Tail} + N_{service}}{m_{STBC} N_{DBPS}} \right\rceil \tag{28-60}$$

For an HE SU PPDU with BCC encoding,

$$N_{SYM} = N_{SYM,init} \tag{28-61}$$

and

$$a = a_{init} \tag{28-62}$$

where a_{init} is define in Equation (28-56).

The number of data bits per symbol in the last OFDM symbol(s) of an HE SU PPDU or HE ER SU PPDU is $N_{DBPS,last} = N_{DBPS,last,init}$, where $N_{DBPS,last,init}$ is define in Equation (28-57).

The number of coded bits per symbol in the last OFDM symbol(s) of an HE SU PPDU or HE ER SU PPDU is given by Equation (28-63).

$$N_{CBPS,\,LAST} = \begin{cases} a \cdot N_{CBPS,\,short}, & \text{if } a < 4 \\ N_{CBPS}, & \text{if } a = 4 \end{cases} \tag{28-63}$$

28.3.11.5.2 LDPC coding

For an HE SU PPDU or HE ER SU PPDU using LDPC coding to encode the Data field, the LDPC code and encoding process described in 19.3.11.7 (LDPC codes) shall be used with the following modifications. First, all bits in the Data field including the scrambled SERVICE, PSDU, and pre-FEC pad bits are encoded, i.e., $N_{pld} = N_{service} + 8 \times \text{APEP\_LENGTH} + N_{PAD,Pre\text{-}FEC}$. Thus, N_{pld} for HE PPDUs shall be computed using Equation (28-64) instead of Equation (19-35).

$$N_{pld} = (N_{SYM,\,init} - m_{STBC}) N_{DBPS} + m_{STBC} N_{DBPS,\,last,\,init} \tag{28-64}$$

where

$$N_{SYM.init} = m_{STBC} \cdot \left\lceil \frac{8 \cdot \text{APEP\_LENGTH} + N_{service}}{m_{STBC} \cdot N_{DBPS}} \right\rceil \tag{28-65}$$

Following the calculation of N_{pld}, N_{avbits} shall be computed using Equation (28-66) instead of Equation (19-36).

$$N_{avbits} = (N_{SYM,\,init} - m_{STBC}) \cdot N_{CBPS} + m_{STBC} \cdot N_{CBPS,\,last,\,init} \tag{28-66}$$

In addition, in step d) of LDPC encoding process as described in 19.3.11.7.5 (LDPC PPDU encoding process), if the following condition is met:

$(N_{punc} > 0.1 \times N_{CW} \times L_{LDPC} \times (1 - R))$ AND $\left(N_{shrt} < 1.2 \times N_{punc} \times \frac{R}{1 - R}\right)$ is true OR if

$N_{punc} > 0.3 \times N_{CW} \times L_{LDPC} \times (1 - R)$ is true,

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then the LDPC Extra Symbol Segment field of HE-SIG-A shall be set to 1, N_{avbits} shall be increased according to the Equation (28-67) instead of Equations (19-39), and N_{punc} shall be recomputed as in Equation (19-40):

$$N_{avbits} = \begin{cases} N_{avbits} + m_{STBC} \cdot (N_{CBPS} - 3N_{CBPS,short}), & \text{if } a_{init} = 3 \\ N_{avbits} + m_{STBC} \cdot N_{CBPS,short}, & \text{otherwise} \end{cases} \quad (28\text{-}67)$$

and then update a and N_{SYM} values by the following Equation (28-68):

$$\begin{cases} N_{SYM} = N_{SYM,init} + m_{STBC} \text{ and } a = 1, & \text{if } a_{init} = 4 \\ N_{SYM} = N_{SYM,init} \text{ and } a = a_{init} + 1, & \text{otherwise} \end{cases} \quad (28\text{-}68)$$

If in step d) of LDPC encoding process as described in 19.3.11.7.5 (LDPC PPDU encoding process), the above mentioned condition is not met, then the LDPC Extra Symbol Segment field in HE-SIG-A shall be set to 0, and

$$\begin{aligned} N_{SYM} &= N_{SYM,init} \\ a &= a_{init} \end{aligned} \quad (28\text{-}69)$$

With the final pre-FEC padding factor value a, update the N_{CBPS} of the last symbol as:

$$N_{CBPS,last} = \begin{cases} a \cdot N_{CBPS,short}, & \text{if } a < 4 \\ N_{CBPS}, & \text{if } a = 4 \end{cases} \quad (28\text{-}70)$$

The number of data bits of the last symbol is calculated as $N_{DBPS,last} = N_{DBPS,last,init}$.

LDPC codes used in HE MU PPDUs shall also follow the definitions in 19.3.11.7 (LDPC codes). Refer to 28.3.11.5.4 (Encoding process for an HE MU PPDU) for a description of the LDPC encoding process for HE MU PPDUs.

28.3.11.5.3 Post-FEC padding

The number of post-FEC padding bits in each of the last m_{STBC} symbol(s) is computed by:

$$N_{PAD,Post\text{-}FEC} = N_{CBPS} - N_{CBPS,last} \quad (28\text{-}71)$$

The last m_{STBC} symbols shall consist of $N_{CBPS,last}$ bits from the FEC output followed by $N_{PAD,Post\text{-}FEC}$ post-FEC padding bits. The values of the post-FEC padding bits are not specified and are left up to implementation.

28.3.11.5.4 Encoding process for an HE MU PPDU

For an HE MU PPDU, all the users shall use a common pre-FEC padding factor value and a common N_{SYM} value. The padding process is described as follows.

First compute initial pre-FEC padding factor value ($a_{init,u}$) for each user u using Equation (28-56), and the initial number of OFDM symbols ($N_{SYM,init,u}$) for each user u using Equation (28-60) if user u is BCC encoded, or Equation (28-65) if user u is LDPC encoded. Among all the users, derive the user index with the longest encoded packet duration, as in Equation (28-72).

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$$u_{\max} = \arg\max_{u=0}^{N_u-1}(N_{SYM,init,u} - m_{STBC} + 0.25 m_{STBC} a_{init,u}) \quad (28\text{-}72)$$

where m_{STBC} is the common STBC setting among all the users, as described in 28.3.11.7 (Segment parser).

Then the common a_{init} and $N_{SYM,init}$ values among all the users are derived by Equation (28-73):

$$\begin{aligned} N_{SYM,init} &= N_{SYM,init,u_{\max}} \\ a_{init} &= a_{init,u_{\max}} \end{aligned} \quad (28\text{-}73)$$

Update each user's initial number of coded bits in its last symbol as below:

$$\begin{aligned} N_{DBPS,last,init,u} &= \begin{cases} a_{init} N_{DBPS,short,u}, \text{ if } a_{init} < 4 \\ N_{DBPS,u}, \text{ if } a_{init} = 4 \end{cases} \\ N_{CBPS,last,init,u} &= \begin{cases} a_{init} N_{CBPS,short,u}, \text{ if } a_{init} < 4 \\ N_{CBPS,u}, \text{ if } a_{init} = 4 \end{cases} \end{aligned} \quad (28\text{-}74)$$

For each user with LDPC encoding, the number of pre-FEC padding bits is computed as in Equation (28-75):

$$\begin{aligned} N_{PAD,\text{Pre-FEC},u} = {} & (N_{SYM,init} - m_{STBC}) N_{DBPS,u} + m_{STBC} N_{DBPS,last,init,u} \\ & - 8 \cdot \text{APEP\_LENGTH}_u - N_{service} \end{aligned} \quad (28\text{-}75)$$

For each user with LDPC encoding, the parameters $N_{pld,u}$ and $N_{avbits,u}$ are computed using Equation (28-76) and Equation (28-77) respectively:

$$N_{pld,u} = (N_{SYM,init} - m_{STBC}) N_{DBPS,u} + m_{STBC} N_{DBPS,last,init,u} \quad (28\text{-}76)$$

$$N_{avbits,u} = (N_{SYM,init} - m_{STBC}) N_{CBPS,u} + m_{STBC} N_{CBPS,last,init,u} \quad (28\text{-}77)$$

For each user with LDPC encoding continue LDPC encoding process as in 19.3.11.7.5 (LDPC PPDU encoding process) starting with the parameters $N_{pld,u}$ and $N_{avbits,u}$. If there is at least one user with LDPC encoding, where step d) of its LDPC encoding process of 19.3.11.7.5 (LDPC PPDU encoding process), meets the following condition:

$(N_{punc,u} > 0.1 \times N_{CW,u} \times L_{LDPC,u} \times (1 - R_u))$ AND $\left(N_{shrt,u} < 1.2 \times N_{punc,u} \times \frac{R_u}{1 - R_u}\right)$ is true OR if

$N_{punc,u} > 0.3 \times N_{CW,u} \times L_{LDPC,u} \times (1 - R_u)$ is true,

where $N_{punc,u}$, $N_{CW,u}$, $L_{LDPC,u}$ and $N_{shrt,u}$ are the LDPC encoding parameters for user u, as defined in 19.3.11.7.5 (LDPC PPDU encoding process), and R_u is the coding rate of user u, then the LDPC Extra Symbol Segment field in HE-SIG-A shall be set to 1, and all the users with LDPC encoding shall increment N_{avbits} and recomputed N_{punc}, by the following two equations once:

$$N_{avbits,u} = \begin{cases} N_{avbits,u} + m_{STBC} \cdot (N_{CBPS} - 3 N_{CBPS,short,u}), \text{ if } a_{init} = 3 \\ N_{avbits,u} + m_{STBC} \cdot N_{CBPS,short,u}, \text{ otherwise} \end{cases} \quad (28\text{-}78)$$

$$N_{punc,u} = \max(0, (N_{CW,u} \times L_{LDPC,u}) - N_{avbits,u} - N_{shrt,u}) \quad (28\text{-}79)$$

Update the common pre-FEC padding factor and N_{SYM} values for all users by the following equation:

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$$\begin{cases} N_{SYM} = N_{SYM,init} + m_{STBC} \text{ and } a = 1, \text{ if } a_{init} = 4 \\ N_{SYM} = N_{SYM,init} \text{ and } a = a_{init} + 1, \text{ otherwise} \end{cases} \quad (28\text{-}80)$$

If none of the users with LDPC encoding in step d) of 19.3.11.7.5 (LDPC PPDU encoding process) meets the above mentioned condition, or if all the users in the HE MU PPDU are BCC encoded, then the LDPC Extra Symbol Segment field in HE-SIG-A shall be set to 0, and the common pre-FEC padding factor and N_{SYM} values for all users shall be updated by Equation (28-81).

$$a = a_{init}, N_{SYM} = N_{SYM,init} \quad (28\text{-}81)$$

For the users with LDPC encoding, $N_{DBPS,last,u} = N_{DBPS,last,init,u}$.

For the users with BCC encoding, update the N_{DBPS} of the last symbol as

$$N_{DBPS,last,u} = \begin{cases} a \cdot N_{DBPS,short,u}, \text{ if } a < 4 \\ N_{DBPS,u}, \text{ if } a = 4 \end{cases} \quad (28\text{-}82)$$

For each user with either LDPC or BCC encoding, update the N_{CBPS} of the last symbol as

$$N_{CBPS,last,u} = \begin{cases} a \cdot N_{CBPS,short,u}, \text{ if } a < 4 \\ N_{CBPS,u}, \text{ if } a_{init} = 4 \end{cases}$$

For the users with BCC encoding, the number of pre-FEC padding bits is shown in Equation (28-83).

$$N_{PAD,\text{Pre-FEC},u} = (N_{SYM} - m_{STBC})N_{DBPS,u} + m_{STBC}N_{DBPS,last,u} - 8 \cdot \text{APEP\_LENGTH}_u - N_{Tail} - N_{service} \quad (28\text{-}83)$$

For each user with either LDPC or BCC encoding, the number of post-FEC padding bits in each of the last m_{STBC} symbol(s) is computed as in Equation (28-84):

$$N_{PAD,\text{Post-FEC},u} = N_{CBPS,u} - N_{CBPS,last,u} \quad (28\text{-}84)$$

Among the pre-FEC padding bits, the MAC delivers a PSDU that fills the available octets in the Data field of the HE PPDU, toward the desired pre-FEC padding boundary, represented by a_{init} for users encoded by LDPC and represented by a for users encoded by BCC, in the last OFDM symbol(s). The PHY then determines the number of pad bits to add and appends them to the PSDU. The number of pre-FEC pad bits added by PHY will always be 0 to 7. The procedure is defined in Equation (28-85) and Equation (28-86).

$$N_{PAD,\text{Pre-FEC},MAC} = 8 \cdot \left\lfloor \frac{N_{PAD,\text{Pre-FEC},u}}{8} \right\rfloor \quad (28\text{-}85)$$

$$N_{PAD,\text{Pre-FEC},PHY} = N_{PAD,\text{Pre-FEC},u} \bmod 8 \quad (28\text{-}86)$$

28.3.11.5.5 Encoding process for an HE TB PPDU

The AP indicates the common N_{SYM}, pre-FEC padding factor, STBC indication and LDPC Extra Symbol Segment fields in the Trigger frame.

For an HE TB PPDU with BCC encoding, follow the HE SU PPDU padding and encoding process as introduced in 28.3.11.2 (Pre-FEC padding process), 28.3.11.5.1 (Binary convolutional coding and puncturing),

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and 28.3.11.5.3 (Post-FEC padding), with initial parameters setting to $N_{SYM,init} = N_{SYM}$, and $a_{init} = a$, where N_{SYM} and a are the common number of symbols and pre-FEC padding factor indicated in the Trigger frame, respectively.

For an HE TB PPDU with LDPC encoding, follow the HE SU PPDU padding and encoding process as introduced in 28.3.11.2 (Pre-FEC padding process), 28.3.11.5.2 (LDPC coding), and 28.3.11.5.3 (Post-FEC padding), with the following exceptions:

When the LDPC Extra Symbol Segment field in the Trigger frame is 1, set the initial parameters following Equation (28-87):

$$\begin{cases} a_{init} = 4 \text{ and } N_{SYM,\,init} = N_{SYM} - m_{STBC}, & \text{if } a = 1 \\ a_{init} = a - 1 \text{ and } N_{SYM,\,init} = N_{SYM}, & \text{otherwise} \end{cases} \tag{28-87}$$

where N_{SYM} and a are the common number of symbols and pre-FEC padding factor indicated in the Trigger frame respectively, and m_{STBC} is 2 if the Trigger frame indicates STBC and 1 otherwise. Then continue with the LDPC encoding process as in 19.3.11.7.5 (LDPC PPDU encoding process), during which in step d) of 19.3.11.7.5 (LDPC PPDU encoding process), always increment N_{avbits} as in Equation (28-67), and always recompute N_{punc} as in Equation (19-40).

When the LDPC Extra Symbol Segment field in the Trigger frame is 0, set initial parameters to $N_{SYM,init} = N_{SYM}$, and $a_{init} = a$, where N_{SYM} and a are the common number of symbols and pre-FEC padding factor indicated in the Trigger frame respectively. Then continue with the LDPC encoding process as in 19.3.11.7.5 (LDPC PPDU encoding process), during which in step d) of 19.3.11.7.5 (LDPC PPDU encoding process), N_{avbits} and N_{punc} are not changed, and $a = a_{init}$.

28.3.11.6 Stream parser

After coding, scrambling, puncturing and post-FEC padding, the data bits are processed in groups of N_{CBPS} bits. Each of these groups is re-arranged into N_{SS} blocks of N_{CBPSS} bits ($N_{SS,u}$ blocks of $N_{CBPSS,u}$ bits in the case of an HE MU transmission). This operation is referred to as “stream parsing” and is described in this subclause.

The description is given in terms of an SU transmission. For MU transmissions, the rearrangements are carried out in the same way per user.

The number of bits assigned to a single axis (real or imaginary) in a constellation point in a spatial stream is denoted by Equation (28-88).

$$s = max(1, \frac{N_{BPSCS}}{2}) \tag{28-88}$$

The sum of these over all streams is $S = N_{SS} \cdot s$.

Consecutive blocks of s bits are assigned to different spatial streams in a round robin fashion.

For the N_{CBPS} bits of each OFDM symbol, S bits from the output of the encoder are divided among all spatial streams, s bits per stream.

Note that for all RU sizes the coded bits per OFDM symbol are always evenly allocated to N_{SS} spatial streams.

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The following equations are an equivalent description to the above procedure. Bit i at the output of the encoder is assigned to input bit k of spatial stream i_{SS} where

$$i = (i_{SS} - 1)s + S \cdot \left\lfloor \frac{k}{s} \right\rfloor + (k \bmod s)$$

$$i_{SS} = 1, 2, \ldots, N_{SS}$$

$$i = 0, 1, \ldots, N_{CBPS} - 1$$

$$k = 0, 1, \ldots, N_{CBPSS} - 1$$

28.3.11.7 Segment parser

The description in this subclause is for an SU transmission. For an MU transmissions, the rearrangements are carried out in the same way but per user.

For a 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz transmission with a 26-, 52-, 106-, 242-, 484- or 996-tone RU, the segment parser is bypassed and the output bits are as specified in Equation (28-89).

$$y_{k,l} = x_k \tag{28-89}$$

where

x_k is bit k of a block of N_{CBPSS} bits, $k = 0$ to $N_{CBPSS} - 1$

l is the frequency subblock index and $l = 0$ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU.

$y_{k,l}$ is bit k of the frequency subblock l

For a 160 MHz and 80+80 MHz transmission with a 2×996-tone RU, the output bits of each stream parser are first divided into blocks of N_{CBPSS} bits ($N_{CBPSS,u}$ bits in the case of an MU transmission). Then, each block is further divided into two frequency subblocks of $N_{CBPSS}/2$ bits as shown in Equation (28-90).

$$y_{k,l} = x_m \tag{28-90}$$

$$m = 2s \cdot \left\lfloor \frac{k}{s} \right\rfloor + l \cdot s + (k \bmod s), \quad k = 0, 1, \ldots, \frac{N_{CBPSS}}{2} - 1 \tag{28-91}$$

and

x_m is bit m of a block of N_{CBPSS} bits and $m = 0, \ldots, N_{CBPSS} - 1$

l is the frequency subblock index and $l = 0, 1$

$y_{k,l}$ is bit k of the frequency subblock l

s is defined in Equation (28-88)

28.3.11.8 BCC interleavers

For ease of explanation, the operation of the interleaver is described only for the SU case. For user u of an MU transmission, the interleaver operates in the same way on the output bits for the user from the stream parser by replacing N_{SS}, N_{CBPSS}, N_{CBPS}, and N_{BPSCS} with $N_{SS,u}$, $N_{CBPSS,u}$, $N_{CBPS,u}$ and $N_{BPSCS,u}$, respectively. That is, the operation of the interleaver is the same as if the transmission were an SU one, consisting of bits from only that user.

The BCC interleaver operation is specified in 21.3.10.8 (BCC interleaver). When DCM is used with BPSK modulation in a 106-tone RU or a 242-tone RU with $N_{SS} = 1$, after the $2 \times N_{DBPS}$ coded bits in each OFDM symbol, 1 padding bit is added before the bits are interleaved. (The interleaver parameters, N_{COL}, N_{ROW}, and

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N_{ROT}, for the Data field depend on the RU size and whether or not DCM is used and are defined in the RU size column of Table 28-31 (BCC interleaver parameters).

Table 28-31—BCC interleaver parameters

DCM	Parameter	RU size (tones)				HE-SIG-A/ HE-SIG-B (tones)
		26	52	106	242	56
Not used	N_{COL}	8	16	17	26	13
	N_{ROW}	$3 \times N_{BPSCS}$	$3 \times N_{BPSCS}$	$6 \times N_{BPSCS}$	$9 \times N_{BPSCS}$	$4 \times N_{BPSCS}$
	N_{ROT}	2	11	29	58	-
Used	N_{COL}	4	8	17	13	13
	N_{ROW}	$3 \times N_{BPSCS}$	$3 \times N_{BPSCS}$	$3 \times N_{BPSCS}$	$9 \times N_{BPSCS}$	$2 \times N_{BPSCS}$
	N_{ROT}	2	2	11	29	-

The interleaver parameters, N_{COL} and N_{ROW}, for the HE-SIG-A and HE-SIG-B fields are defined in the HE-SIG-A/HE-SIG-B column of Table 28-31 (BCC interleaver parameters).

NOTE—DCM is not used on the HE-SIG-A field.

28.3.11.9 Constellation mapping

The mapping between the input bits of the constellation mapper and complex constellation points for BPSK, QPSK, 16-QAM, 64-QAM and 256-QAM is defined in 21.3.10.9 (Constellation mapping).

1024-QAM is optional for SU and MU for RUs equal to or larger than 242 subcarriers. For 1024-QAM, the mapping of the bits at the output of the interleaver to the complex constellation points is defined in Figure 28-35 (Constellation bit encoding for 1024-QAM (1st quadrant)), Figure 28-36 (Constellation bit

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encoding for 1024-QAM (2nd quadrant)), Figure 28-37 (Constellation bit encoding for 1024-QAM (3rd quadrant)) and Figure 28-38 (Constellation bit encoding for 1024-QAM (4th quadrant)).

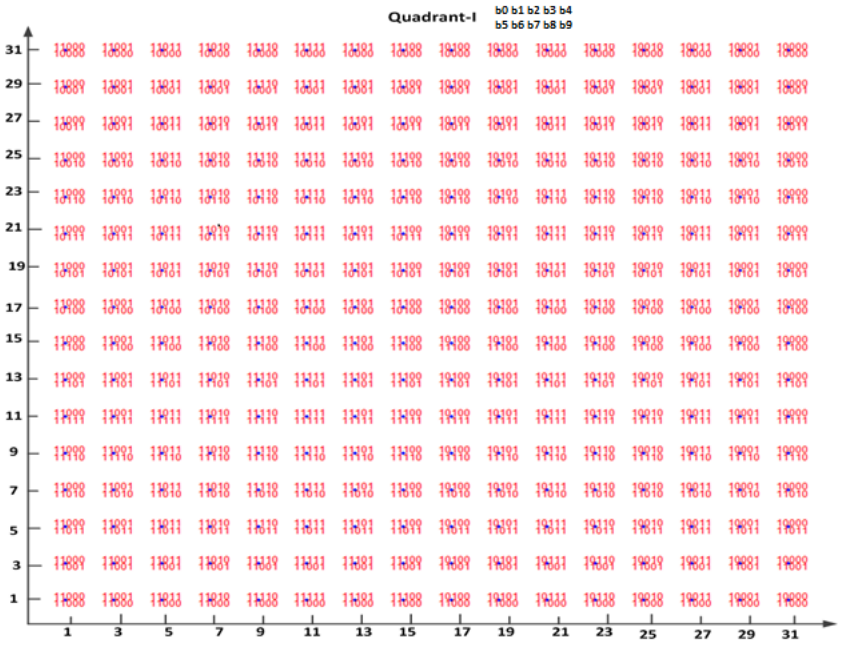


Figure 28-35—Constellation bit encoding for 1024-QAM (1st quadrant)



Figure 28-36—Constellation bit encoding for 1024-QAM (2nd quadrant)

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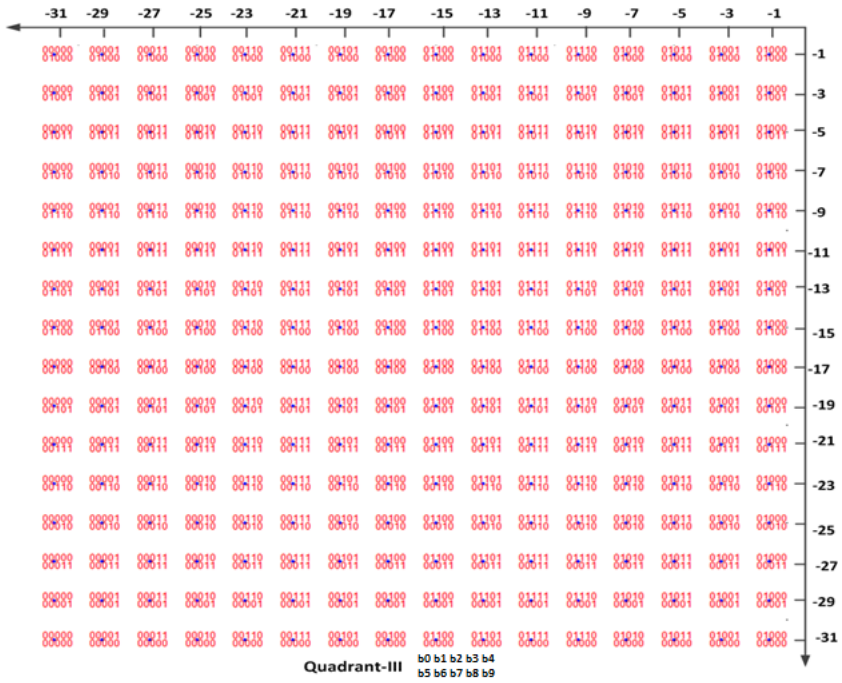


Figure 28-37—Constellation bit encoding for 1024-QAM (3rd quadrant)



Figure 28-38—Constellation bit encoding for 1024-QAM (4th quadrant)

The normalization factor K_{mod} for 1024 QAM is $1/\sqrt{682}$.

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Dual subcarrier modulation (DCM) is an optional modulation scheme for the HE-SIG-B and Data fields. DCM can be applied to an HE SU PPDU and an HE ER SU PPDU. In an HE MU PPDU or HE TB PPDU, DCM can be applied only to RUs containing data for 1 user.

DCM is only applied to HE-MCSs 0, 1, 3 and 4. DCM is applied only with $N_{SS} = 1$ or $N_{SS} = 2$ (in the case of single user RU in an HE MU PPDU, $N_{SS,r,u} = 1$ or $N_{SS,r,u} = 2$). DCM is not applied with MU-MIMO or with STBC.

When DCM is employed, bit sequences are mapped to a pair of symbols $(d_k, d_{q(k)})$ where k is in the range of $0 \le k \le N_{SD} - 1$ and $q(k)$ is in the range of $N_{SD} \le q(k) \le 2N_{SD} - 1$ in order to exploit frequency diversity for a 996-tone or smaller RU, and $0 \le k \le N_{SD}/2 - 1$ and $q(k)$ is in the range of $N_{SD}/2 \le q(k) \le N_{SD} - 1$ for a 2×996-tone RU. To maximize the frequency diversity, the indices of a pair of DCM subcarriers $(k, q(k))$ is $q(k) = k + N_{SD}$. The N_{SD} here refers to the N_{SD} with DCM = 1, which is half the value of N_{SD} with DCM = 0.

For BPSK modulation with DCM, the input stream is broken into groups of N_{CBPS} or $N_{CBPS,u}$ bits $(B_0, B_1, \ldots, B_{N_{CBPS,u}-1})$. Each bit B_k is BPSK modulated to a sample d_k. This generates the samples for the lower half of the data subcarriers. For the upper half of the subcarriers, the samples are generated as $d_{k+N_{SD}} = d_k \times e^{j(k+N_{SD})\pi}$, $k = 0, 1, \ldots, N_{SD} - 1$. The N_{SD} here refers to the N_{SD} with DCM = 1, which is half the value of N_{SD} with DCM = 0.

For QPSK modulation with DCM, the input stream is broken into groups of N_{CBPS} or $N_{CBPS,u}$ bits $(B_0, B_1, \ldots, B_{N_{CBPS,u}-1})$. Each pair of bits (B_{2k}, B_{2k+1}) is QPSK modulated to a symbol d_k. This generates the constellation points for the lower half the data subcarriers in the RU. For the upper half of the data subcarriers in the RU, $d_{k+N_{SD}} = conj(d_k)$, where *conj*() represents the complex conjugate operation. The N_{SD} here refers to the N_{SD} with DCM = 1, which is half the value of N_{SD} with DCM = 0.

For 16-QAM modulation with DCM, the input stream is broken into groups of N_{CBPS} or $N_{CBPS,u}$ bits $(B_0, B_1, \ldots, B_{N_{CBPS,u}-1})$. A group of 4 bits $(B_{4k}, B_{4k+1}, B_{4k+2}, B_{4k+3})$ is 16-QAM modulated to a sample d_k as described in 17.3.5.8 (Subcarrier modulation mapping). This is the sample on subcarrier k in the lower half. In the upper half, the sample $d_{k+N_{SD}}$ on subcarrier $k + N_{SD}$ is obtained by 16-QAM modulating a permutation of the bits $(B_{4k}, B_{4k+1}, B_{4k+2}, B_{4k+3})$. Specifically, $d_{k+N_{SD}}$ is obtained by applying the 16-QAM modulation procedure in 18.3.5.8 to the bit group $(B_{4k+1}, B_{4k}, B_{4k+3}, B_{4k+2})$. The N_{SD} here refers to the N_{SD} with DCM = 1, which is half the value of N_{SD} with DCM = 0.

28.3.11.10 Space-time block coding

For an HE PPDU, STBC is allowed only with single spatial stream and two space-time streams, and its application is as indicated by the STBC field in HE-SIG-A. In an HE MU PPDU, STBC coding is used in all RUs or not used in any of the RUs. If in an RU, DL MU-MIMO is applied, STBC shall not be used in any RU in the HE MU PPDU.

The STBC encoding process is described in 21.3.10.9.4 (Space-time block coding), with $N_{SS,0} = 1$ and $N_{STS,0} = 2$.

28.3.11.11 LDPC tone mapper

The LDPC tone mapping shall be performed on all LDPC encoded streams mapped in an RU as described in this subclause. LDPC tone mapping shall not be performed on streams that are encoded using BCC. When DCM is applied to LDPC encoded streams, $D_{\text{TM\_DCM}}$ shall be applied on both the lower half data subcarriers in an RU and the upper half data subcarriers of the RU. The LDPC tone-mapping distance parameters

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D_{TM} and D_{TM_DCM} are constant for each RU size and the values for different RU sizes are given in Table 28-32 (LDPC tone mapping distance for each RU size).

Table 28-32—LDPC tone mapping distance for each RU size

Parameter	RU Size (tones)						
	26	52	106	242	484	996	2×996
D_{TM}	1	3	6	9	12	20	20
D_{TM_DCM}	1	1	3	9	9	14	14

NOTE—The LDPC tone mapping parameters D_{TM} and D_{TM_DCM} are applied for each frequency subblock, $l = 0$ and $l = 1$.

For an HE PPDU without DCM, the LDPC tone mapping for the LDPC encoded stream for user u in the r-th RU is done by permuting the stream of complex numbers generated by the constellation mappers (see 28.3.11.9 (Constellation mapping)) as defined by Equation (28-92).

$$d''_{t(k),\,i,\,n,\,l,\,r,\,u} = d'_{k,\,i,\,n,\,l,\,r,\,u} \tag{28-92}$$

where

$$k = \begin{cases} 0, 1, \ldots, N_{SD} - 1 & \text{for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ 0, 1, \ldots, N_{SD}/2 - 1 & \text{for a 2×996-tone RU} \end{cases}$$

$$i = 1, \ldots, N_{SS,\,r,\,u}$$

$$n = 0, 1, \ldots, N_{SYM} - 1$$

$$l = \begin{cases} 0 & \text{for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ 0, 1 & \text{for a 2×996-tone RU} \end{cases}$$

$$u = 0, \ldots, N_{user,\,r} - 1$$

$$r = 0, \ldots, N_{RU} - 1$$

N_{SD} is the number of data tones in the r-th RU

$$t(k) = \begin{cases} D_{TM}\left(k \bmod \dfrac{N_{SD}}{D_{TM}}\right) + \left\lfloor \dfrac{k \cdot D_{TM}}{N_{SD}} \right\rfloor, & \text{for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ D_{TM}\left(k \bmod \dfrac{N_{SD}/2}{D_{TM}}\right) + \left\lfloor \dfrac{k \cdot D_{TM}}{N_{SD}/2} \right\rfloor, & \text{for a 2×996-tone RU} \end{cases}$$

For an HE PPDU with DCM, the LDPC tone mapping for the LDPC encoded stream corresponding to user u in the r-th RU is done by permuting the stream of complex numbers generated by the constellation mappers (see 28.3.11.9 (Constellation mapping)) as defined by Equation (28-93).

$$d''_{t(k),\,i,\,n,\,l,\,r,\,u} = d'_{k,\,i,\,n,\,l,\,r,\,u} \tag{28-93}$$

where

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$$k = \begin{cases} 0, 1, \ldots, 2N_{SD} - 1 \text{ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ 0, 1, \ldots, N_{SD} - 1 \text{ for a 2×996-tone RU} \end{cases}$$

$$i = 1, \ldots, N_{SS,r,u}$$

$$n = 0, 1, \ldots, N_{SYM} - 1$$

$$l = \begin{cases} 0 \text{ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ 0, 1 \text{ for a 2×996-tone RU} \end{cases}$$

$$u = 0, \ldots, N_{user,r} - 1$$

$$r = 0, \ldots, N_{RU} - 1$$

N_{SD} is the number of data tones in the r-th RU when DCM is applied

For a 26-, 52-, 106-, 242-, 484- and 996-tone RU,

$$t(k) = \begin{cases} D_{TM\_DCM}\left(k \bmod \frac{N_{SD}}{D_{TM\_DCM}}\right) + \left\lfloor \frac{k \cdot D_{TM\_DCM}}{N_{SD}} \right\rfloor, & \text{for } k < N_{SD} \\ D_{TM\_DCM}\left((k - N_{SD}) \bmod \frac{N_{SD}}{D_{TM\_DCM}}\right) + \left\lfloor \frac{(k - N_{SD}) \cdot D_{TM\_DCM}}{N_{SD}} \right\rfloor + N_{SD}, & \text{for } k \geq N_{SD} \end{cases}$$

For a 2×996-tone RU,

$$t(k) = \begin{cases} D_{TM\_DCM}\left(k \bmod \frac{N_{SD}/2}{D_{TM\_DCM}}\right) + \left\lfloor \frac{k \cdot D_{TM\_DCM}}{N_{SD}/2} \right\rfloor, & \text{for } 0 \leq k < N_{SD}/2 - 1 \\ D_{TM\_DCM}\left((k - N_{SD}/2) \bmod \frac{N_{SD}/2}{D_{TM\_DCM}}\right) + \left\lfloor \frac{(k - N_{SD}/2) \cdot D_{TM\_DCM}}{N_{SD}/2} \right\rfloor + N_{SD}/2, & \text{for } N_{SD}/2 \leq k \leq N_{SD} - 1 \end{cases}$$

$D_{TM_DCM}$is the LDPC tone mapping distance for the r-th RU when DCM is applied.

NOTE—LDPC tone mapper for a 26-, 52-, 106-, 242-, 484- and 996-tone RU is defined as one segment. LDPC tone mapping is performed separately for the upper and lower 80 MHz frequency segments of a 2×996-tone RU as indicated by the frequency subblock index l.

Since LDPC tone mapping is not performed on BCC coded streams, for BCC coded spatial streams, Equation (28-94) applies.

$$d''_{k,i,n,l,r,u} = d'_{k,i,n,l,r,u} \tag{28-94}$$

where

$$k = \begin{cases} 0, 1, \ldots, N_{SD} - 1 \text{ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ 0, 1, \ldots, N_{SD}/2 - 1 \text{ for a 2×996-tone RU} \end{cases}$$

$$i = 1, \ldots, N_{SS,r,u}$$

$$n = 0, 1, \ldots, N_{SYM} - 1$$

$$l = \begin{cases} 0 \text{ for a 26-, 52-, 106-, 242-, 484- and 996-tone RU} \\ 0, 1 \text{ for a 2×996-tone RU} \end{cases}$$

$$u = 0, \ldots, N_{user,r} - 1$$

$$r = 0, \ldots, N_{RU} - 1$$

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28.3.11.12 Segment deparser

For a 26-, 52-, 106-, 242-, 484- and 996-tone RU, the segment deparsing is not performed and $d^{(i_{Seg})}_{k,i,n,r,u}$ is specified in Equation (28-95).

$$d^{(i_{Seg})}_{k,i,n,r,u} = d''_{k,i,n,0,r,u}, \quad \text{if } 0 \le k \le N_{SD}-1, i_{Seg} = 0 \tag{28-95}$$

For a 2×996-tone RU in a 160 MHz HE PPDU, the two frequency subblocks at the output of the LDPC tone mapper are combined into one frequency segment as specified in Equation (28-96).

$$d^{(i_{Seg})}_{k,i,n,r,u} = \begin{cases} d''_{k,i,n,0,r,u}, & \text{if } 0 \le k \le \dfrac{N_{SD}}{2}-1 \\ d''_{k-\frac{N_{SD}}{2},i,n,l,r,u}, & \text{if } \dfrac{N_{SD}}{2} \le k \le N_{SD}-1 \end{cases}, i_{Seg} = 0 \tag{28-96}$$

For a 2×996-tone RU in an 80+80 MHz HE PPDU, the segment deparsing is not performed and $d^{(i_{Seg})}_{k,i,n,r,u}$ is specified in Equation (28-97).

$$d^{(i_{Seg})}_{k,i,n,r,u} = d''_{k,i,n,i_{Seg},r,u}, \quad \text{if } 0 \le k \le N_{SD}-1, i_{Seg} = 0, 1 \tag{28-97}$$

NOTE—As per Table 21-7 (center frequency for frequency segment iSeg = 0), $f_c^{(0)}$ is always less than $f_c^{(1)}$ in case of 80+80 MHz HE PPDU. Hence, $d''_{k,i,n,0,r,u}$ (frequency subblock 0) is always transmitted in the frequency segment lower in frequency, while $d''_{k,i,n,1,r,u}$ (frequency subblock 1) is always transmitted in the frequency segment higher in frequency.

28.3.11.13 Pilot subcarriers

For a user transmitting on the *i*-th 26-tone RU in a given PPDU BW, two pilot subcarriers shall be inserted in subcarriers $k \in K_{R26_i}$, where K_{R26_i} is given by the *i*-th pilot index set in the row of given PPDU BW of Table 28-33 (Pilot indices for a 26-tone RU).

Table 28-33—Pilot indices for a 26-tone RU

PPDU BW	K_{R26_i}
20 MHz, *i* = 1:9	−116/−102, −90/−76, −62/−48, −36/−22, −10/10, 22/36, 48/62, 76/90, 102/116
40 MHz, *i* = 1:18	−238/−224, −212/−198, −184/−170, −158/−144, −130/−116, −104/−90, −78/−64, −50/−36, −24/−10, 10/24, 36/50, 64/78, 90/104, 116/130, 144/158, 170/184, 198/212, 224/238
80 MHz, *i* = 1:37	−494/−480, −468/−454, −440/−426, −414/−400, −386/−372, −360/−346, −334/−320, −306/−292, −280/−266, −252/−238, −226/−212, −198/−184, −172/−158, −144/−130, −118/−104, −92/−78, −64/−50, −38/−24, −10/10, 24/38, 50/64, 78/92, 104/118, 130/144, 158/172, 184/198, 212/226, 238/252, 266/280, 292/306, 320/334, 346/360, 372/386, 400/414, 426/440, 454/468, 480/494
160 MHz, *i* = 1:74	{pilot subcarrier indices in 80 MHz −512, pilot subcarrier indices in 80 MHz +512}

The pilot mapping P_n^k for the subcarrier *k* for symbol *n* shall be as specified in Equation (28-98).

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$$P_n^{K_{R26_i}} = \{\Psi_{n \bmod 2}, \Psi_{(n+1) \bmod 2}\}$$
$$P_n^{k \notin K_{R26_i}} = 0 \quad (28\text{-}98)$$

where

Ψ_m is defined in Table 28-34 (The 2 pilot values for a 26-tone RU)

Table 28-34—The 2 pilot values for a 26-tone RU

Ψ_0	Ψ_1
1	−1

For a user transmitting on the *i*-th 52-tone RU in a given PPDU BW, four pilot subcarriers shall be inserted in subcarriers $k \in K_{R52_i}$, where K_{R52_i} is given by the *i*-th pilot index set in the row of given PPDU BW of Table 28-35 (Pilot indices for 52-tone RU transmission).

Table 28-35—Pilot indices for 52-tone RU transmission

PPDU BW	K_{R52_i}
20 MHz, *i* = 1:4	−116/−102/−90/−76, −62/−48/−36/−22, 22/36/48/62, 76/90/102/116
40 MHz, *i* = 1:8	−238/−224/−212/−198, −184/−170/−158/−144, −104/−90/−78/−64, −50/−36/−24/−10, 10/24/36/50, 64/78/90/104, 144/158/170/184, 198/212/224/238
80 MHz, *i* = 1:16	−494/−480/−468/−454, −440/−426/−414/−400, −360/−346/−334/−320, −306/−292/−280/−266, −252/−238/−226/−212, −198/−184/−172/−158, −118/−104/−92/−78, −64/−50/−38/−24, 24/38/50/64, 78/92/104/118, 158/172/184/198, 212/226/238/252, 266/280/292/306, 320/334/346/360, 400/414/426/440, 454/468/480/494
160 MHz, *i* = 1:32	{pilot subcarrier indices in 80 MHz −512, pilot subcarrier indices in 80 MHz +512}

The pilot mapping P_n^k for the subcarrier *k* for symbol *n* shall be as specified in Equation (28-99).

$$P_n^{K_{R52_i}} = \{\Psi_{n \bmod 4}, \Psi_{(n+1) \bmod 4}, \Psi_{(n+2) \bmod 4}, \Psi_{(n+3) \bmod 4}\}$$
$$P_n^{k \notin K_{R52_i}} = 0 \quad (28\text{-}99)$$

where

Ψ_m is defined in Table 28-36 (The 4 pilot values in a 52- and 106-tone RU)

Table 28-36—The 4 pilot values in a 52- and 106-tone RU

Ψ_0	Ψ_1	Ψ_2	Ψ_3
1	1	1	−1

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For a user transmitting on the *i*-th 106-tone RU in a given PPDU BW, four pilot subcarriers shall be inserted at subcarriers $k \in K_{R106_i}$, where K_{R106_i} is given by the *i*-th pilot index set in the row of given PPDU BW of Table 28-37 (Pilot indices for 106-tone RU transmission).

Table 28-37—Pilot indices for 106-tone RU transmission

PPDU BW	K_{R106_i}
20 MHz, *i* = 1:2	−116/−90/−48/−22, 22/48/90/116
40 MHz, *i* = 1:4	−238/−212/−170/−144, −104/−78/−36/−10, 10/36/78/104, 144/170/212/238
80 MHz, *i* = 1:8	−494/−468/−426/−400, −360/−334/−292/−266, −252/−226/−184/−158, −118/−92/−50/−24, 24/50/92/118, 158/184/226/252, 266/292/334/360, 400/426/468/494
160 MHz, *i* = 1:16	{pilot subcarrier indices in 80 MHz −512, pilot subcarrier indices in 80 MHz +512}

The pilot mapping P_n^k for the subcarrier *k* for symbol *n* shall be as specified in Equation (28-100).

$$\begin{aligned} P_n^{K_{R106_i}} &= \{\Psi_{n \bmod 4}, \Psi_{(n+1) \bmod 4}, \Psi_{(n+2) \bmod 4}, \Psi_{(n+3) \bmod 4}\} \\ P_n^{k \notin K_{R106_i}} &= 0 \end{aligned} \tag{28-100}$$

where

Ψ_m is defined in Table 28-36 (The 4 pilot values in a 52- and 106-tone RU)

For a user transmitting on the *i*-th 242-tone RU in a given PPDU BW, eight pilot subcarriers shall be inserted in subcarriers $k \in K_{R242_i}$, where K_{R242_i} is given by the *i*-th pilot index set in the row of given PPDU BW of Table 28-38 (Pilot indices for 242-tone RU transmission).

Table 28-38—Pilot indices for 242-tone RU transmission

PPDU BW	K_{R242_i}
20 MHz, *i* = 1	−116/−90/−48/−22/22/48/90/116
40 MHz, *i* = 1:2	−238/−212/−170/−144/−104/−78/−36/−10, 10/36/78/104/144/170/212/238
80 MHz, *i* = 1:4	−494/−468/−426/−400/−360/−334/−292/−266,−252/−226/−184/−158/−118/−92/−50/−24, 24/50/92/118/158/184/226/252, 266/292/334/360/400/426/468/494
160 MHz, *i* = 1:8	{pilot subcarrier indices in 80 MHz −512, pilot subcarrier indices in 80 MHz +512}

The pilot mapping P_n^k for the subcarrier *k* for symbol *n* shall be as specified in Equation (28-101).

$$\begin{aligned} P_n^{K_{R242_i}} &= \{\Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \\ &\quad \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}\} \\ P_n^{k \notin K_{R242_i}} &= 0 \end{aligned} \tag{28-101}$$

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where

Ψ_m is defined in Table 28-39 (The 8 pilot values in a 242-tone RU)

Table 28-39—The 8 pilot values in a 242-tone RU

Ψ_0	Ψ_1	Ψ_2	Ψ_3	Ψ_4	Ψ_5	Ψ_6	Ψ_7
1	1	1	−1	−1	1	1	1

For a 484-tone RU transmission, the pilot mapping for 8 pilots in 242-tone RU is replicated in the two 242-RUs of the 484-tone RU transmission. Specifically, for a user transmitting on the *i*-th 484-tone RU in a given PPDU BW, sixteen pilot subcarriers shall be inserted in subcarriers $k \in K_{R484_i}$, where K_{R484_i} is given by the *i*-th pilot index set in the row of given PPDU BW of Table 28-40 (Pilot indices for 484-tone RU transmission).

Table 28-40—Pilot indices for 484-tone RU transmission

PPDU BW	K_{R484_i}
40 MHz, i = 1	−238/−212/−170/−144/−104/−78/−36/−10/10/36/78/104/144/170/212/238
80 MHz, i = 1:2	−494/−468/−426/−400/−360/−334/−292/−266/−252/−226/−184/−158/−118/−92/−50/−24, 24/50/92/118/158/184/226/252/266/292/334/360/400/426/468/494
160 MHz, i = 1:4	{pilot subcarrier indices in 80 MHz −512, pilot subcarrier indices in 80 MHz +512}

The pilot mapping P_n^k for the subcarrier *k* for symbol *n* shall be as specified in Equation (28-102).

$$\begin{aligned} P_n^{K_{R484_i}} = \{ & \Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \\ & \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}, \\ & \Psi_{(n+8) \bmod 8}, \Psi_{(n+9) \bmod 8}, \Psi_{(n+10) \bmod 8}, \Psi_{(n+11) \bmod 8}, \\ & \Psi_{(n+12) \bmod 8}, \Psi_{(n+13) \bmod 8}, \Psi_{(n+14) \bmod 8}, \Psi_{(n+15) \bmod 8} \} \\ P_n^{k \notin K_{R484_i}} = 0 & \end{aligned} \quad (28\text{-}102)$$

where

Ψ_m is defined in Table 28-39 (The 8 pilot values in a 242-tone RU)

For a 996-tone RU transmission, the pilot mapping for its 16 pilots is the same as the mapping for 484-tone RU transmission. Specifically, for a user transmitting on the *i*-th 996-tone RU in a given PPDU BW, sixteen

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pilot subcarriers shall be inserted in subcarriers $k \in K_{R996_i}$, where K_{R996_i} is given by the *i*-th pilot index set in the row of given PPDU BW of Table 28-41 (Pilot indices for 996-tone RU transmission).

Table 28-41—Pilot indices for 996-tone RU transmission

PPDU BW	K_{R996_i}
80 MHz, i = 1	−468/−400/−334/−266/−226/−158/−92/−24/24/92/158/226/266/334/400/468
160 MHz, i = 1:2	{for i = 1 pilot subcarrier indices in 80 MHz −512, for i = 2 pilot subcarrier indices in 80 MHz +512}

The pilot mapping P_n^k for the subcarrier *k* for symbol *n* shall be as specified in Equation (28-103).

$$\begin{aligned} P_n^{K_{R996_i}} = \{ & \Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \\ & \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}, \\ & \Psi_{(n+8) \bmod 8}, \Psi_{(n+9) \bmod 8}, \Psi_{(n+10) \bmod 8}, \Psi_{(n+11) \bmod 8}, \\ & \Psi_{(n+12) \bmod 8}, \Psi_{(n+13) \bmod 8}, \Psi_{(n+14) \bmod 8}, \Psi_{(n+15) \bmod 8} \} \\ P_n^{k \notin K_{R996_i}} = 0 & \end{aligned} \quad (28\text{-}103)$$

where

Ψ_m is defined in Table 28-39 (The 8 pilot values in a 242-tone RU)

For a 160 MHz transmission (equivalently two 996-tone RU transmissions), the 80 MHz (equivalently 996-tone RU) pilot mapping is replicated in the two 80 MHz subchannels of the 160 MHz transmission. Specifically, 32 pilot subcarriers shall be inserted in subcarriers $k \in K_{\mathrm{R2\times996}_i}$, where $K_{\mathrm{R2\times996}_i}$ is given by {–980, –912, –846, –778, –738, –670, –604, –536, –488, –420, –354, –286, –246, –178, –112, –44, 44, 112, 178, 246, 286, 354, 420, 488, 536, 604, 670, 738, 778, 846, 912, 980}. The pilot mapping P_n^k for the subcarrier *k* for symbol *n* shall be as specified in Equation (28-104).

$$\begin{aligned} P_n^{K_{R2\times996_i}} = \{ & \Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \\ & \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}, \\ & \Psi_{(n+8) \bmod 8}, \Psi_{(n+9) \bmod 8}, \Psi_{(n+10) \bmod 8}, \Psi_{(n+11) \bmod 8}, \\ & \Psi_{(n+12) \bmod 8}, \Psi_{(n+13) \bmod 8}, \Psi_{(n+14) \bmod 8}, \Psi_{(n+15) \bmod 8}, \\ & \Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \Psi_{(n+2) \bmod 8}, \Psi_{(n+3) \bmod 8}, \\ & \Psi_{(n+4) \bmod 8}, \Psi_{(n+5) \bmod 8}, \Psi_{(n+6) \bmod 8}, \Psi_{(n+7) \bmod 8}, \\ & \Psi_{(n+8) \bmod 8}, \Psi_{(n+9) \bmod 8}, \Psi_{(n+10) \bmod 8}, \Psi_{(n+11) \bmod 8}, \\ & \Psi_{(n+12) \bmod 8}, \Psi_{(n+13) \bmod 8}, \Psi_{(n+14) \bmod 8}, \Psi_{(n+15) \bmod 8} \} \\ P_n^{k \notin K_{R2\times996_i}} = 0 & \end{aligned} \quad (28\text{-}104)$$

where

Ψ_m is defined in Table 28-39 (The 8 pilot values in a 242-tone RU)

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For a noncontiguous 80+80 MHz transmission, each frequency segment shall follow the 80 MHz pilot subcarrier allocation and values defined for 996-tone RU in 80 MHz transmission as specified in Equation (28-103).

The above pilot mapping shall be copied to all space-time streams before the space-time stream cyclic shifts are applied.

28.3.11.14 OFDM modulation

The time domain waveform of the Data field of an HE PPDU that is not an HE TB PPDU, from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ and frequency segment i_{Seg}, shall be as defined in Equation (28-105).

$$r_{\text{HE-Data}}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{\sum_{r=0}^{N_{RU}-1} \alpha_r^2 |K_r|}} \sum_{n=0}^{N_{SYM}-1} w_{T_{\text{HE-Data}}}(t - nT_{SYM}) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r}{\sqrt{N_{STS,r,total}}} \sum_{k \in K_r} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left(\left[Q_k^{(i_{Seg})} \right]_{i_{TX}, (M_{r,u}+m)} (\tilde{D}_{k,m,n,r}^{(i_{Seg},u)} + p_{n+2+N_{\text{HE-SIG-A}}+N_{\text{HE-SIG-B}}} P_n^k) \cdot \exp(j2\pi k \Delta_{F,\text{HE}} (t - nT_{SYM} - T_{GI,Data} - T_{CS,\text{HE}}(M_{r,u}+m))) \right) \quad (28\text{-}105)$$

where

p_n is defined in 17.3.5.10 (OFDM modulation)

P_n^k is defined in 28.3.11.13 (Pilot subcarriers)

$T_{CS,\text{HE}}(M_{r,u}+m)$ represents the cyclic shift for space-time stream $M_{r,u}+m$ as defined in 28.3.10.2.2 (Cyclic shift for HE modulated fields)

$T_{GI,Data}$ is the guard interval duration as defined in Table 28-12 (Timing-related constants)

$\tilde{D}_{k,m,n,r}^{(i_{Seg},u)}$ is the transmitted constellation for user u in the r-th RU at subcarrier k, space-time stream m, and Data field OFDM symbol n and is defined by Equation (28-106).

$$\tilde{D}_{k,m,n,r}^{(i_{Seg},u)} = \begin{cases} 0, k \in K_{\text{Pilot}} \\ \tilde{d}_{M_r(k),m,n,r,u}^{(i_{Seg})}, \text{otherwise} \end{cases} \quad (28\text{-}106)$$

where

K_{Pilot} is the set of subcarrier indices of pilot subcarriers, as defined in 28.3.3.4 (Pilot subcarriers)

$M_r(k)$ is defined in Equation (28-107)

$$M_r(k) = k - K_{r,\min} - \left| \{ k' : K_{r,\min} \le k' < k \} \cap K_{\text{Pilot}} \right| \quad (28\text{-}107)$$

where

$K_{r,min}$ is the minimum value of the set K_r

$|\Phi|$ is the cardinality of a set Φ

NOTE – $M_r(k)$ translates a subcarrier index k ($-N_{SR} \le k \le N_{SR,r}$) into the index of data symbols in a transmission over RU r ($0 \le M_r(k) \le N_{SD,r}$). The subcarrier index k for the data tone is first offset by the minimum value of subcarrier index $K_{r,min}$ (for the lower edge tone) in this RU, and then subtracted by the number of pilot subcarriers falling in between the data tone and the edge tone.

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In a noncontiguous 80+80 MHz transmission, each frequency segment shall follow the 80 MHz HE subcarrier mapping as specified in 28.3.9 (Mathematical description of signals).

The time domain waveform of the Data field of an HE TB PPDU for user u in the r-th RU from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ shall be as defined in Equation (28-108).

$$r_{\text{HE-Data}}^{(i_{Seg} i_{TX})}(t) = \frac{1}{\sqrt{|K_r|}} \sum_{n=0}^{N_{SYM}-1} w_{T_{\text{HE-Data}}}(t - nT_{SYM}) \frac{1}{\sqrt{N_{STS,\,r,\,u}}} \sum_{k \in K_r} \sum_{m=1}^{N_{STS,\,r,\,u}} \left(\left[Q_{k,\,u}^{(i_{Seg})} \right]_{i_{TX},\,m} (\tilde{D}_{k,\,m,\,n,\,r}^{(i_{Seg},\,u)} + p_{n+4} P_n^k) \cdot \exp(j2\pi k \Delta_{F,\,\text{HE}}(t - nT_{SYM} - T_{GI,\,Data} - T_{CS,\,HE}(M_{r,\,u} + n \right. \tag{28-108}$$

where

$Q_{k,\,u}^{(i_{Seg})}$ is defined in 28.3.9 (Mathematical description of signals).

28.3.11.15 Dual carrier modulation

Dual carrier modulation (DCM) modulates the same information on a pair of sub-carriers. DCM is an optional modulation scheme for the HE-SIG-B and Data fields. DCM is only applied to HE-MCSs and HE-SIG-B-MCSs with indices 0, 1, 3 and 4.

The constellation mapper for DCM is defined in 28.3.11.9 (Constellation mapping). The LDPC tone mapper for DCM is defined in 28.3.11.11 (LDPC tone mapper). The BCC interleaver for DCM is defined in 28.3.11.8 (BCC interleavers).

28.3.11.16 Midamble

Midamble is applied for HE PPDU transmissions in channels with high Doppler, and it is an optional feature. Midamble is defined only when $N_{STS} \le 4$. The recipient may use the midamble to compensate the channel estimation when it is varying fast in channels with high Doppler.

When the Doppler subfield of the HE-SIG-A field is set to 1 in an HE SU PPDU, HE ER SU PPDU, or HE MU PPDU, or when the Doppler subfield in the Common Info field is set to 1 in the Trigger frame preceding an HE TB PPDU, midambles are inserted to the HE Data field every M_{MA} OFDM symbols, where M_{MA} is the midamble periodicity in number of OFDM symbols, whose value is either 10 or 20, as indicated by HE-SIG-A field, defined in 28.3.10.7 (HE-SIG-A), or indicated by the Common Info field in the Trigger frame, defined in 9.3.1.23 (Trigger frame format).

An HE SU PPDU or HE ER SU PPDU with the Doppler subfield of the HE-SIG-A field set to 1 may only be sent to a STA that sets the Doppler Rx subfield in the HE PHY Capabilities Information field of the HE Capabilities element to 1, as defined in 9.4.2.237.3 (HE PHY Capabilities Information field). Otherwise it shall not be sent.

An HE MU PPDU with the Doppler subfield of the HE-SIG-A field is set to 1 is allowed only when all the recipient STAs of the HE MU PPDU set the Doppler Rx subfield in the HE PHY Capabilities Information field of the HE Capabilities element to 1, as defined in 9.4.2.237.3 (HE PHY Capabilities Information field).

A Trigger frame with the Doppler subfield in the Common Info field set to 1 is allowed only when all the recipient STAs of the Trigger frame set the Doppler Tx subfield in the HE PHY Capabilities Information field in the HE Capabilities element to 1, as defined in 9.4.2.237.3 (HE PHY Capabilities Information field).

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Each midamble is the same as the HE-LTF field(s) in the preamble of the same PPDU as defined in 28.3.10.10 (HE-LTF), as shown in Figure 28-39 (HE PPDU with midamble).

An HE SU PPDU with midamble containing 1x HE-LTF may only be sent to STAs that set the Doppler Rx subfield to 1 and the Midamble Rx 2x and 1x HE-LTF subfield to 1 in the HE Capabilities fields and the HE SU PPDU With 1x HE-LTF And 0.8 us GI subfield to 1, as defined in 9.4.2.237.3 (HE PHY Capabilities Information field). Otherwise it shall not be sent.

An HE ER SU PPDU with midamble containing 1x HE-LTF may only be sent to a STA that sets the Doppler Rx subfield to 1 and the Midamble Rx 2x and 1x HE-LTF subfield to 1 in the HE Capabilities fields and the HE ER SU PPDU With 1x HE-LTF And 0.8 us GI subfield to 1, as defined in 9.4.2.237.3 (HE PHY Capabilities Information field). Otherwise it shall not be sent.

An HE PPDU with midamble containing 2x HE-LTF may only be sent to STA(s) that set the Doppler Rx subfield to 1 and the Midamble Rx 2x and 1x HE-LTF subfield to 1 in the HE Capabilities fields, as defined in 9.4.2.237.3 (HE PHY Capabilities Information field). Otherwise it shall not be sent.

An HE PPDU with midamble containing 4x HE-LTF may be sent to a STA that sets the Doppler Rx subfield to 1 in the HE Capabilities fields, as defined in 9.4.2.237.3 (HE PHY Capabilities Information field). Otherwise it shall not be sent.

A non-AP HE STA that sets the Doppler Tx field to 1 in the HE Capabilities fields, as defined in 9.4.2.237.3 (HE PHY Capabilities Information field), shall be able to transmit midambles with 4x HE-LTF(s) or 2x HE-LTF(s) in an HE TB PPDU, and shall be able to transmit midambles with 1x HE-LTF(s) in a full bandwidth UL MU-MIMO PPDU if it sets the Full Bandwidth UL MU-MIMO field to 1 in the HE Capabilities field.

When midamble is used in an HE PPDU, the number of space-time streams in this PPDU shall not be more than that indicated by the Midamble Rx Max NSTS field in the HE Capabilities fields set by the recipient STA(s), as defined in 9.4.2.237.3 (HE PHY Capabilities Information field).

The scrambling and encoding process of the bits in the Data field OFDM symbols before and after each midamble are the same as the case where midamble is not present.

When present, the number of midamble periods, N_{MA} , in a PPDU is calculated by Equation (28-109).

$$N_{MA} = max\left(0, \left\lceil \frac{N_{SYM} - 1}{M_{MA}} \right\rceil - 1\right) \quad \text{(28-109)}$$

where N_{SYM} is as defined in 28.3.11.5 (Coding).

As shown in Figure 28-39 (HE PPDU with midamble), the first midamble is inserted right after the M_{MA}-th OFDM symbol in HE Data field, and there is no midamble inserted after the last data OFDM symbol if

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mod(N_{SYM}, M_{MA}) = 0. At the end of a HE PPDU, if mod(N_{SYM}, M_{MA}) = 1, there is also no midamble inserted before the last OFDM symbol, as shown in Figure 28-40 (Midamble at the end of an HE PPDU).

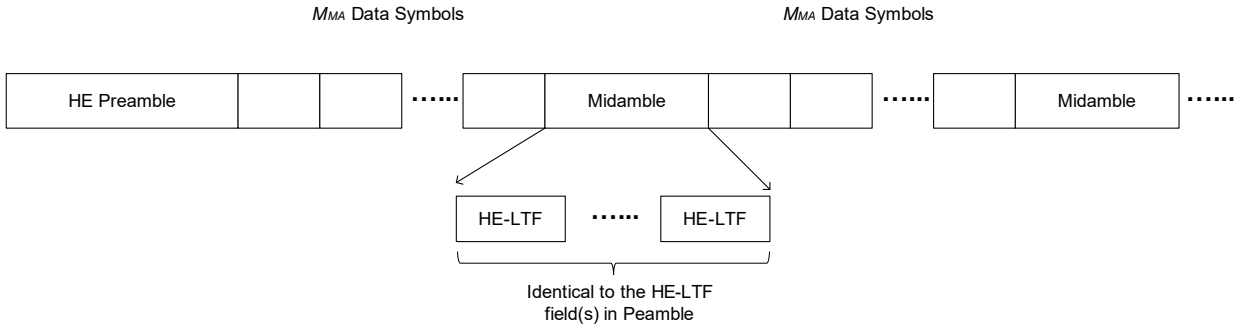


Figure 28-39—HE PPDU with midamble

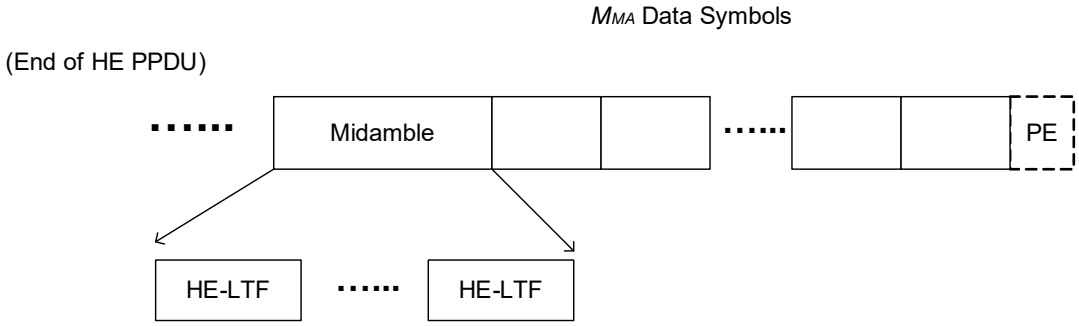


Figure 28-40—Midamble at the end of an HE PPDU

In an HE SU PPDU, HE ER SU PPDU, or HE MU PPDU, if the Doppler field of HE-SIG-A field is set to 1 and $N_{SYM} \leq M_{MA} + 1$, there is no midamble present in the current PPDU. In this case, the Doppler subfield setting to 1 indicates that the current channel between the transmitter and the recipient is with high channel Doppler, and recommends that midamble may be used for the PPDUs of the reverse link.

28.3.12 Packet extension

An HE PPDU may have a Packet Extension (PE) field appended at the end of the PPDU, with possible durations being 0 μs, 4 μs, 8 μs, 12 μs, or 16 μs. The PE field provides additional receive processing time at the end of the HE PPDU. The PE field, when present, shall be transmitted with the same average power as the Data field and shall not cause significant power leakage outside of the spectrum used by the Data field. Other than that, its content is arbitrary.

The duration of the PE field for an HE SU PPDU, HE ER SU PPDU or HE MU PPDU is determined by both the pre-FEC padding factor value in the last OFDM symbol(s) of the Data field, and the TXVECTOR parameter NOMINAL_PACKET_PADDING.

For an HE SU or HE ER SU PPDU, the nominal T_{PE} value ($T_{PE,nominal}$) is given by Table 28-42 (Nominal TPE values). In this case, a in Table 28-42 (Nominal TPE values) is given by Equation (28-68) or Equation (28-69).

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For an HE MU PPDU, the nominal T_{PE} value ($T_{PE,nominal}$) is given by $T_{PE,nominal} = \max_u T_{PE,nominal,u}$, where $T_{PE,nominal,u}$ is the nominal T_{PE} value for user u and is also given by Table 28-42 (Nominal TPE values). In this case, a in Table 28-42 (Nominal TPE values) is given by Equation (28-80) or Equation (28-81).

Table 28-42—Nominal T_{PE} values

a	TXVECTOR parameter NOMINAL_PACKET_PADDING (HE SU PPDU or HE ER SU PPDU) or NOMINAL_PACKET_PADDING[*u*] (HE MU PPDU)		
	0 µs	**8 µs**	**16 µs**
1	0 µs	0 µs	4 µs
2	0 µs	0 µs	8 µs
3	0 µs	4 µs	12 µs
4	0 µs	8 µs	16 µs

The duration of the PE field, T_{PE}, may take values of 0, 4, 8, 12 or 16 µs. T_{PE} for an HE SU, HE ER SU or HE MU PPDU shall not be less than $T_{PE,nominal}$. T_{PE} for an HE SU, HE ER SU or HE MU PPDU should be equal to $T_{PE,nominal}$ to minimize the packet extension overhead. Figure 28-41 (PE field duration of an HE SU PPDU or HE ER SU PPDU when TXVECTOR parameter NOMINAL_PACKET_PADDING is 8 µs and TPE = TPE,nominal) and Figure 28-42 (PE field duration of an HE SU PPDU or HE ER SU PPDU when TXVECTOR parameter NOMINAL_PACKET_PADDING is 16 µs TPE = TPE,nominal) show examples of the PE field duration in an HE SU PPDU or HE ER SU PPDU where the TXVECTOR parameter NOMINAL_PACKET_PADDING has values of 8 µs and 16 µs, respectively, and $T_{PE} = T_{PE,nominal}$.

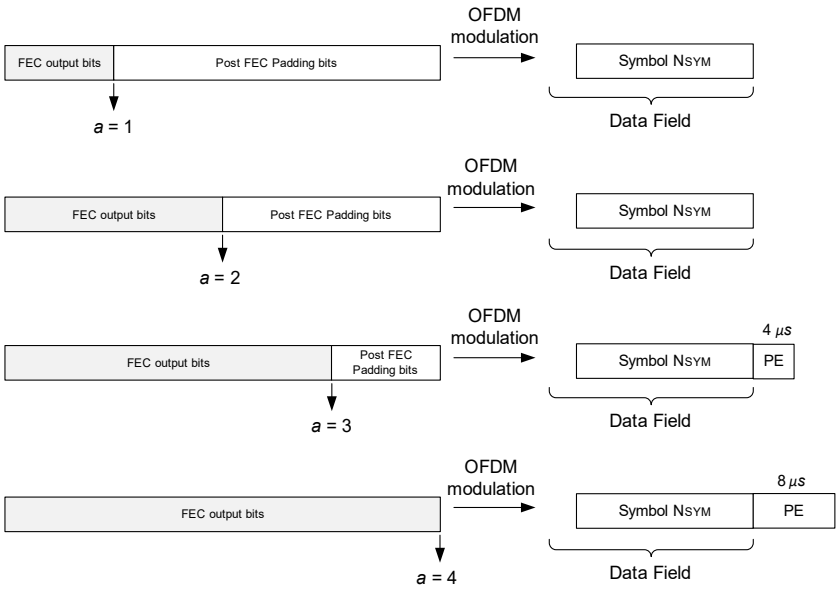


Figure 28-41—PE field duration of an HE SU PPDU or HE ER SU PPDU when TXVECTOR parameter NOMINAL_PACKET_PADDING is 8 µs and $T_{PE} = T_{PE,nominal}$

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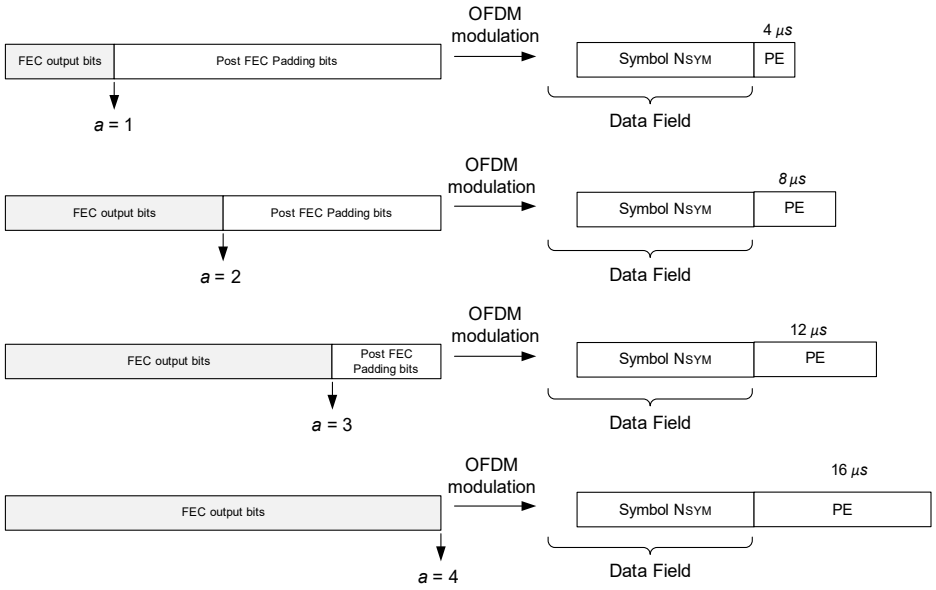


Figure 28-42—PE field duration of an HE SU PPDU or HE ER SU PPDU when TXVECTOR parameter NOMINAL_PACKET_PADDING is 16 μs $T_{PE} = T_{PE,nominal}$

T_{PE} for an HE NDP PPDU is 4 μs.

When transmitting an HE TB PPDU for which the TXVECTOR parameter TRIGGER_METHOD is TRIGGER_FRAME, each transmitter of an HE TB PPDU shall append a PE field with a duration T_{PE} calculated using Equation (28-110) except for the HE TB NDP feedback which has a PE_duration = 0.

$$T_{PE} = \left\lfloor \frac{\left(\frac{\text{LENGTH} + m + 3}{3} \times 4 - T_{\text{HE-PREAMBLE}}\right) - N_{SYM} T_{SYM} - N_{MA} N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}}{4} \right\rfloor \times 4 \quad (28\text{-}110)$$

where

$m = 2$ for an HE TB PPDU

$$N_{SYM} = \left\lfloor \left(\frac{\text{LENGTH} + m + 3}{3} \times 4 - T_{\text{HE-PREAMBLE}} - N_{MA} N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}\right) / T_{SYM} \right\rfloor - b_{\text{PE-Disambiguity}}$$

LENGTH is the value indicated by Length subfield of the Common Info field in the Trigger frame

$b_{\text{PE-Disambiguity}}$ is indicated by the PE Disambiguity subfield in the Packet Extension subfield of the Common Info field in the Trigger frame (see Table 9-25g (Subfields of the Packet Extension subfield))

$$T_{\text{HE-PREAMBLE}} = T_{\text{RL-SIG}} + T_{\text{HE-SIG-A}} + T_{\text{HE-STF-T}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}$$

$T_{\text{HE-STF-T}}$, $T_{\text{HE-LTF-SYM}}$, $T_{\text{RL-SIG}}$ and $T_{\text{HE-SIG-A}}$ are defined in Table 28-12 (Timing-related constants)

N_{MA} is the number of midamble periods in the current PPDU.

There are multiple options for computing N_{MA}, one example is as follows. The duration of one midamble period is defined in Equation (28-111).

$$T_{MA} = M_{MA} T_{SYM} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}} \quad (28\text{-}111)$$

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where M_{MA} is the midamble periodicity indicated by the Number of HE-LTF Symbols And Midamble Periodicity subfield of the Common Info field in the Trigger frame. N_{MA} in Equation (28-109) is then given by Equation (28-112).

$$N_{MA} = \begin{cases} 0, \text{ if Doppler} = 0 \\ max\left(0, \left\lfloor \left(\frac{LENGTH + 3 + m}{3} \times 4 - T_{\text{HE-PREAMBLE}} - (b_{\text{PE-Diambiguity}} + 2) \cdot T_{SYM} \right) / T_{MA} \right\rfloor\right), \text{ if Doppler} = 1 \end{cases} \quad (28\text{-}112)$$

where Doppler is indicated by the Doppler subfield of the Common Info field of the Trigger frame.

When transmitting an HE TB PPDU for which the TXVECTOR parameter TRIGGER_METHOD is UMRS, each transmitter of the HE TB PPDU shall append a PE field with the duration T_{PE} equal to the value specified in the TXVECTOR parameter DEFAULT_PE_DURATION.

The PE Disambiguity field of the HE-SIG-A field for an HE SU, HE ER SU (see Table 28-15 (HE-SIG-A field of an HE SU PPDU and HE ER SU PPDU)) or HE MU PPDU (see Table 28-19 (HE-SIG-A field of an HE MU PPDU)) shall be set to 1 if the condition in Equation (28-113) is met, otherwise it shall be set to 0.

The PE Disambiguity subfield of the Packet Extension subfield for an HE TB PPDU (see Table 9-25g (Subfields of the Packet Extension subfield)) shall be set to 1 if the condition in Equation (28-113) is met, otherwise it shall be set to 0.

$$T_{PE} + 4 \times \left(\left\lceil \frac{\text{TXTIME} - SignalExtension - 20}{4} \right\rceil - \left(\frac{\text{TXTIME} - SignalExtension - 20}{4} \right) \right) \geq T_{SYM} \quad (28\text{-}113)$$

where

T_{PE} is the PE field duration

T_{SYM} is the symbol duration of the Data field as defined in 28.3.8 (Timing-related parameters)

TXTIME (in μs) is defined in 28.4.3 (TXTIME and PSDU_LENGTH calculation)

SignalExtension is 0 μs when TXVECTOR parameter NO_SIG_EXTN is true and is aSignalExtension as defined in Table 19-25 (HT PHY characteristics) when TXVECTOR parameter NO_SIG_EXTN is false

The receiver computes N_{SYM}, T_{PE} and N_{MA} using Equation (28-114), Equation (28-115) and Equation (28-116), respectively.

$$N_{SYM} = \left\lfloor \left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 - T_{\text{HE-PREAMBLE}} - N_{MA} N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}} \right) / T_{SYM} \right\rfloor - b_{\text{PE-Disambiguity}} \quad (28\text{-}114)$$

$$T_{PE} = \left\lfloor \frac{\left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 - T_{\text{HE-PREAMBLE}} \right) - N_{SYM} T_{SYM} - N_{MA} N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}}{4} \right\rfloor \times 4 \quad (28\text{-}115)$$

where

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$$T_{\text{HE-PREAMBLE}} = \begin{cases} T_{\text{RL-SIG}} + T_{\text{HE-SIG-A}} + T_{\text{HE-STF-T}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}, \text{ for an HE TB PPDU} \\ T_{\text{RL-SIG}} + T_{\text{HE-SIG-A}} + T_{\text{HE-STF-NT}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}, \text{ for an HE SU PPDU} \\ T_{\text{RL-SIG}} + T_{\text{HE-SIG-A}} + N_{\text{HE-SIG-B}} T_{\text{HE-SIG-B}} + T_{\text{HE-STF-NT}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}, \text{ for an HE MU PPDU} \\ T_{\text{RL-SIG}} + T_{\text{HE-SIG-A-R}} + T_{\text{HE-STF-NT}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}, \text{ for an HE ER SU PPDU} \end{cases}$$

$T_{\text{RL-SIG}}$, $T_{\text{HE-STF-T}}$, $T_{\text{HE-STF-NT}}$, $T_{\text{HE-LTF-SYM}}$, $T_{\text{HE-SIG-A}}$, $T_{\text{HE-SIG-A-R}}$, $T_{\text{HE-SIG-B}}$ are defined in Table 28-12 (Timing-related constants)

$N_{\text{HE-SIG-B}}$, $N_{\text{HE-LTF}}$ are defined in Table 28-15 (Frequently used parameters)

$b_{\text{PE-Disambiguity}}$ is PE Disambiguity subfield of the HE-SIG-A field for an HE SU, HE ER SU or HE MU PPDU, and an indicated value of PE Disambiguity subfield in the Packet Extension subfield of the Common Info field in the Trigger frame (see Table 9-25g (Subfields of the Packet Extension subfield)) for an HE TB PPDU.

N_{MA} may be computed by multiple methods, one example of which is given in Equation (28-116).

$$N_{MA} = \begin{cases} 0, \text{ if Doppler} = 0 \\ max\left(0, \left\lfloor \left(\frac{LENGTH + 3 + m}{3} \times 4 - T_{\text{HE-PREAMBLE}} - (b_{\text{PE-Diambiguity}} + 2) \cdot T_{SYM} \right) / T_{MA} \right\rfloor \right), \text{ if Doppler} = 1 \end{cases} \quad (28\text{-}116)$$

where

T_{MA} is defined in Equation (28-111) except that M_{MA} is the midamble periodicity indicated by the Nsts And Midamble Periodicity subfield of the HE-SIG-A field in an HE SU PPDU and HE ER SU PPDU, or by the Number Of HE-LTF Symbols And Midamble Periodicity subfield of the HE-SIG-A field in an HE MU PPDU.

Doppler is indicated by the Doppler field of HE-SIG-A field.

28.3.13 Non-HT duplicate transmission

When the TXVECTOR parameter FORMAT is NON_HT and the TXVECTOR parameter NON_HT_MODULATION is NON_HT_DUP_OFDM, the transmitted PPDU is a non-HT duplicate. Non-HT duplicate transmission is used to transmit to non-HT OFDM STAs, HT STAs, VHT STAs and HE STAs that may be present in a part of a 40 MHz, 80 MHz, or 160 MHz channel (see Table 21-2 (Interpretation of FORMAT, NON_HT Modulation and CH_BANDWIDTH parameters)). The RL-SIG, HE-SIG-A, HE-SIG-B, HE-STF, and HE-LTF fields are not transmitted.

In a 40 MHz non-HT duplicate transmission, the Data field shall be as defined by Equation (28-55).

For 80 MHz and 160 MHz non-HT duplicate transmissions, the Data field shall be as defined by Equation (21-101).

In a noncontiguous 80+80 MHz non-HT duplicate transmission, data transmission in each frequency segment shall be as defined for an 80 MHz non-HT duplicate transmission in Equation (21-101).

28.3.14 Transmit requirements for an HE TB PPDU

28.3.14.1 Introduction

HE TB PPDU transmissions are preceded by a Trigger frame from the AP. Since multiple transmitters take part in an HE TB PPDU transmission, transmission time, frequency, sampling symbol clock, and power pre-correction by the participating STAs is necessary to mitigate synchronization and interference issues at the AP. Frequency and sampling clock pre-corrections are needed to prevent inter-carrier interference. Power

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pre-correction is necessary to control interference between HE TB PPDU transmissions from participating STAs. An AP may schedule in the same HE TB PPDU transmission both Class A and Class B devices. A STA participating in HE TB PPDU transmissions shall support power pre-correction as described in 28.3.14.2 (Power pre-correction) and shall meet the pre-correction accuracy requirements described in 28.3.14.3 (Pre-correction accuracy requirements).

28.3.14.2 Power pre-correction

Each STA that is scheduled in the Trigger frame calculates the UL transmit power, Tx_{pwr}^{STA}, of the HE TB PPDU for the assigned MCS using Equation (28-117).

$$Tx_{pwr}^{STA} = PL_{DL} + Target_{RSSI} \quad (28\text{-}117)$$

where

PL_{DL} represents DL pathloss

$Target_{RSSI}$ represents the target receive signal power averaged over the AP's antenna connectors for the HE TB PPDU. $Target_{RSSI}$ is the value, in dBm, of Target RSSI subfield of User Info field in Trigger frame, the encoding of which is specified in Table 9-25i (Target RSSI subfield encoding).

NOTE—A value of 127 in the Target RSSI subfield indicates that the HE TB PPDU is transmitted at its maximum transmit power for the assigned MCS.

Each STA computes PL_{DL} using Equation (28-118).

$$PL_{DL} = Tx_{pwr}^{AP} - DL_{RSSI} \quad (28\text{-}118)$$

where

Tx_{pwr}^{AP} represents the AP's combined transmit power at the antenna connectors of all the transmit antennas used to transmit the Trigger frame and normalized to 20 MHz bandwidth. Tx_{pwr}^{AP} is dBm value of AP Tx Power subfield of the Common Info field in Trigger frame, the encoding of which is specified in Table 9-25f (AP Tx Power subfield encoding).

DL_{RSSI} represents the measured received power from the non-HE portion of the HE PPDU preamble of the Trigger frame at the STA normalized to 20 MHz bandwidth. DL_{RSSI} is an average of the received power over the antennas on which the average PL_{DL} is being computed.

A STA that applies beamforming (BF) in the UL should take the BF gain into account when calculating the transmit power needed to meet the target RSSI.

The UL transmit power of the HE TB PPDU is further subject to a STA's minimum and maximum transmit power limit due to hardware capability, regulatory requirements and local maximum transmit power levels (see 11.8.5 (Specification of regulatory and local maximum transmit power levels)) as well as non-802.11 in-device coexistence requirements.

A STA that is scheduled in a Trigger frame includes its UL power headroom in the HE TB PPDU following the rules defined in 27.5.3.3 (STA behavior for UL MU operation).

28.3.14.3 Pre-correction accuracy requirements

A STA that transmits an HE TB PPDU shall support per chain max(P–32, –10) dBm as the minimum transmit power, where P is the maximum power, in dBm, that the STA can transmit at the antenna connector of

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that chain using MCS 0 while meeting the TX EVM and spectral mask requirements. A STA transmitting at and above the minimum power shall support the EVM requirements for MCS 7.

A STA that transmits an HE TB PPDU shall support the absolute transmit power requirements and the RSSI measurement accuracy requirements defined in Table 28-43 (Transmit power and RSSI measurement accuracy). The absolute transmit power accuracy is applicable for the entire range of transmit power that the

Table 28-43—Transmit power and RSSI measurement accuracy

Parameter	Minimum Requirement		Comments
	Class A	Class B	
Absolute transmit power accuracy	±3 dB	±9 dB	Accuracy of achieving a specified transmit power.
RSSI measurement accuracy	±3 dB	±5 dB	The difference between the RSSI and the received power. Requirements are valid from minimum Rx to maximum Rx input power.
Relative transmit power accuracy	N/A	±3 dB	Accuracy of achieving a change in transmit power for consecutive HE TB PPDU. The relative transmit power accuracy is applicable only to Class B devices.

STA is capable of. The RSSI accuracy requirements shall be applied to receive signal level range from −82 dBm to −20 dBm in 2.4 GHz and −82 dBm to −30 dBm in 5 GHz. The requirements are for nominal (room) temperature conditions. The RSSI shall be measured during the reception of the non-HE portion of the HE PPDU preamble.

A STA that transmits an HE TB PPDU shall pre-compensate for carrier frequency offset (CFO) error and symbol clock error. After compensation, the absolute value of residual CFO error with respect to the PPDU carrying the associated Trigger frame shall not exceed 350 Hz for data subcarriers when measured as the 10% point of the complementary cumulative distribution function (CCDF) of CFO errors in AWGN at a received power of −60 dBm in the primary 20 MHz. The residual CFO error measurement shall be made on the HE TB PPDU following the HE-SIG-A field. The symbol clock error shall be pre-compensated by the same ppm amount as CFO error.

A STA that transmits an HE TB PPDU in response to a triggering PPDU (PPDU containing a Trigger frame or a frame containing a UMRS Control field) from an AP shall ensure that the arrival time of the HE TB PPDU at the AP is within ±0.4 μs of TXTIME + aSIFSTime + RTD from the transmission start time of the triggering PPDU, where TXTIME is that of the triggering PPDU and RTD is the round-trip delay between the AP and the STA.

NOTE—TXTIME contains the SignalExtension, thus TXTIME + aSIFSTime is equivalent to 16 μs after the end of transmission of the triggering PPDU at the AP. The STA is not expected to measure or compensate for the RTD when transmitting the HE TB PPDU.

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28.3.15 SU-MIMO and DL MU-MIMO beamforming

28.3.15.1 General

SU-MIMO and DL MU-MIMO beamforming are techniques used by a STA with multiple antennas (the beamformer) to steer signals using knowledge of the channel to improve throughput. With SU-MIMO beamforming all space-time streams in the transmitted signal are intended for reception at a single STA in an RU. With DL MU-MIMO beamforming, disjoint subsets of the space-time streams are intended for reception at different STAs in an RU of size greater than or equal to 106-tones.

For SU-MIMO and DL MU-MIMO beamforming in RU r, the receive signal vector in subcarrier k (where subcarrier k is one of the subcarriers in RU r, $k \in K_r$) at beamformee u, $\boldsymbol{y}_{k,u} = [y_{k,0}, y_{k,1}, \ldots, y_{k,N_{RX_u}-1}]^T$, is shown in Equation (28-119), where $\boldsymbol{x}_k = [\boldsymbol{x}_{k,0}^T, \boldsymbol{x}_{k,1}^T, \ldots, \boldsymbol{x}_{k,N_{user,r}-1}^T]^T$ denotes the transmit signal vector in subcarrier k for all $N_{user,r}$ beamformees, with $\boldsymbol{x}_{k,u} = [x_{k,0}, x_{k,1}, \ldots, x_{k,N_{STS,r,u}-1}]^T$ being the transmit signal for beamformee u.

$$\boldsymbol{y}_{k,u} = \boldsymbol{H}_{k,u} \times [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}] \times \boldsymbol{x}_k + \boldsymbol{n} \quad (28\text{-}119)$$

where

$\boldsymbol{H}_{k,u}$ is the channel matrix from the beamformer to beamformee u in subcarrier k with dimensions $N_{RX_u} \times N_{TX}$

N_{RX_u} is the number of receive antennas at beamformee u

$Q_{k,u}$ is a steering matrix for beamformee u in subcarrier k with dimensions $N_{TX} \times N_{STS,r,u}$

$N_{user,r}$ is the number of HE MU PPDU recipients (see Table 28-15 (Frequently used parameters)) in RU r

$\boldsymbol{n}$ is a vector of additive noise and may include interference

The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ can be determined by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0, 1, \ldots, N_{user,r} - 1$. The feedback report format is described in 9.4.1.63 (HE Compressed Beamforming Report field) and 9.4.1.64 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission.

For SU-MIMO beamforming, the steering matrix Q_k can be determined from the beamforming feedback matrix V_k that is sent back to the beamformer by the beamformee using the compressed beamforming feedback matrix format as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix). The feedback report format is described in 9.4.1.63 (HE Compressed Beamforming Report field).

28.3.15.2 Beamforming feedback matrix *V*

Upon receipt of an HE NDP PPDU, the beamformee computes a set of matrices for feedback to the beamformer as described in 21.3.11.2 (Beamforming Feedback Matrix V). The eligible beamformees shall remove the space-time stream CSD in Table 21-11 (Cyclic shift values for the VHT modulated fields of a PPDU) from the measured channel before computing a set of matrices for feedback to the beamformer.

The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k in RU r shall be compressed in the form of angles using the method described in 19.3.12.3.6 (Compressed beamforming feedback matrix). The angles, $\phi(k,u)$ and $\psi(k,u)$, are quantized according to Table 9-68 (Quantization of angles). The number of bits for quantization is set by the beamformer, i.e., HE AP. The number of bits for quantization, tone grouping factor, and the number of columns in the HE Compressed beamforming feedback are set by the beamformee, i.e., non-AP STA, only if the NDP Announcement frame contains only one STA Info field. The compressed beamforming feedback matrix as defined in 19.3.12.3.6 (Compressed beamforming

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feedback matrix) is the only Clause 28 (High Efficiency (HE) PHY specification) beamforming feedback matrix defined.

The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP.

After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (19-79). For SU-MIMO beamforming, the beamformer uses $V_{k,0}$, matrix to determine the steering matrix Q_k. For DL MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ using $V_{k,u}$ and $\Delta SNR_{k,u}$ $(0 \le u \le N_{user,r}-1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific.

28.3.15.3 CQI-only feedback

Whenever the HE NDP Announcement frame is requesting a CQI-only feedback, upon receipt of the HE NDP, the beamformee computes HE CQI-only feedback as described in 9.4.1.65 (HE CQI-only Report field). The CQI-only feedback $CQI_{s,r,u}$, in RU r for space-time stream s shall be estimated using the method described in 9.4.1.65 (HE CQI-only Report field). The CQI values to be fed back are derived from quantized SNRs according to Table 9-76h (Average SNR of RU index k for space-time stream i subfield). The beamformee shall transmit the HE CQI-only feedback for space-time stream 1, …, Nc for each of the RU indices for which the CQI-only report is being requested by the beamformer. After receiving the CQI information, the beamformer may use it to identify the best range of RUs for compressed beamforming feedback or for RU assignment during subsequent MU transmissions. The actual use is implementation specific.

28.3.16 HE sounding NDP PPDU

NDP is the only HE sounding format.

The format of an HE NDP PPDU is shown in Figure 28-43 (HE NDP PPDU format).

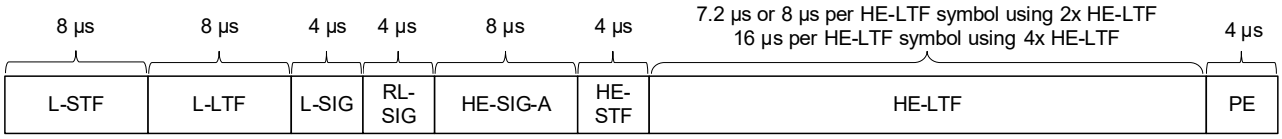


Figure 28-43—HE NDP PPDU format

NOTE—The number of HE-LTF symbols in the HE NDP is determined by the Nsts field in HE SIG-A.

The HE NDP PPDU has the following properties:

— Uses the HE SU PPDU format but without the Data field

— Has a Packet Extension field that is 4 µs in duration

It is mandatory to support the 2x HE-LTF with $T_{GI1,Data}$ and 2x HE-LTF with $T_{GI2,Data}$. It is optional to support the 4x HE-LTF with $T_{GI4,Data}$. The other combinations of HE-LTF modes and GI durations are disallowed.

If the Beamformed field in HE-SIG-A of an HE NDP PPDU is 1, then the receiver of the HE NDP PPDU shall not perform channel smoothing when generating the compressed beamforming feedback report.

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28.3.17 HE TB NDP feedback PPDU

The HE TB NDP feedback PPDU is used to carry the NDP feedback report information as introduced in 27.5.6 (NDP feedback report procedure). The PPDU structure of an HE TB NDP feedback PPDU is shown in Figure 28-44 (HE TB NDP feedback PPDU format).

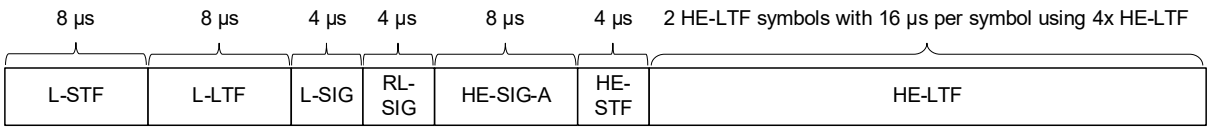


Figure 28-44—HE TB NDP feedback PPDU format

The HE TB NDP feedback PPDU has the following properties:

— Uses the HE TB PPDU format but without the Data field and with PE_duration = 0

— Has two 4x HE-LTF symbols

— 4x HE-LTF, $T_{GI4,Data}$ is the only HE-LTF mode and GI duration combination for the HE-LTF

— The generation of HE-LTF symbols for the HE TB NDP feedback PPDU was defined in 28.3.10.10 (HE-LTF)

28.3.18 Transmit specification

28.3.18.1 Transmit spectral mask

The bandwidth of the spectral mask applied to an HE SU PPDU, an HE TB PPDU and an HE MU PPDU with the Bandwidth subfield of the HE-SIG-A field equal to 0, 1, 2 or 3 shall be determined by the bandwidth indicated in the Bandwidth subfield of the HE-SIG-A field. The bandwidth of the spectral mask applied to an HE ER SU PPDU is 20 MHz. The bandwidth of the spectral mask applied to an HE MU PPDU with the Bandwidth subfield of the HE-SIG-A field equal to 4 or 5 is 80 MHz. The bandwidth of the spectral mask applied to an HE MU PPDU with the Bandwidth subfield of the HE-SIG-A field equal to 6 or 7 is 160 MHz. All HE PPDU formats shall be compliant with the transmit spectral mask described in this section.

NOTE 1—In the presence of additional regulatory restrictions, the device has to meet both the regulatory requirements and the mask defined in this subclause.

NOTE 2—Transmit spectral mask figures in this subclause are not drawn to scale.

NOTE 3—For rules regarding TX center frequency leakage levels, see 28.3.18.4.2 (Transmit center frequency leakage). The spectral mask requirements in this subclause do not apply to the RF LO.

For a 20 MHz mask PPDU of HE format, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 19.5 MHz, −20 dBr at 10.5 MHz frequency offset, −28 dBr at 20 MHz frequency offset, and −40 dBr at 30 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets between 9.75 and 10.5 MHz, 10.5 and 20 MHz, and 20 and 30 MHz shall be linearly interpolated in dB domain from the requirements for 9.75 MHz, 10.5 MHz, 20 MHz, and 30 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectral mask and −53 dBm/MHz at any frequency offset. Figure 28-45 (Example transmit spectral mask for

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a 20 MHz mask PPDU) shows an example of the resulting overall spectral mask when the −40 dBr spectrum level is above −53 dBm/MHz.

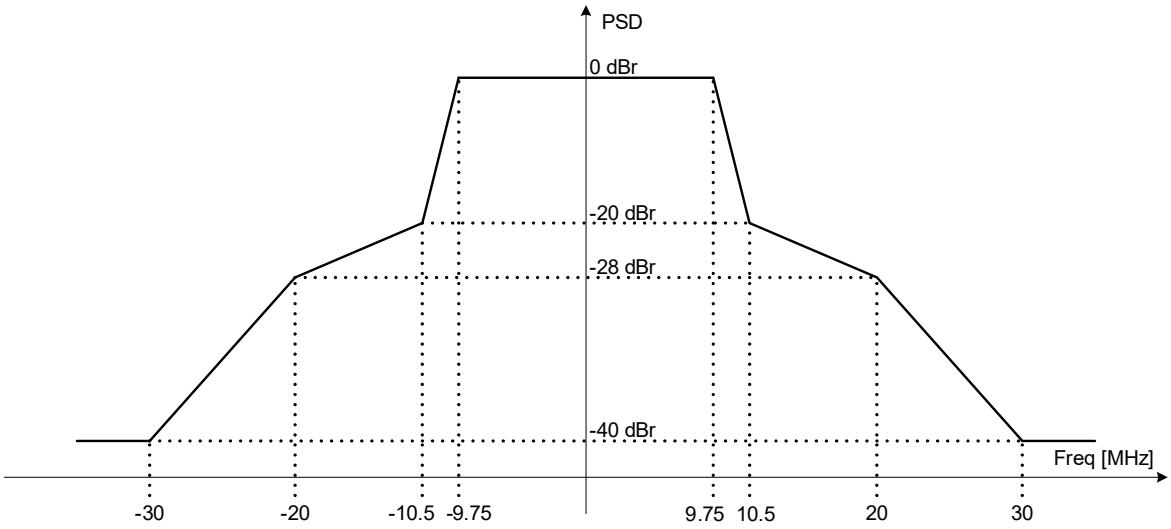


Figure 28-45—Example transmit spectral mask for a 20 MHz mask PPDU

For a 40 MHz mask PPDU of HE format, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 39 MHz, −20 dBr at 20.5 MHz frequency offset, −28 dBr at 40 MHz frequency offset, and −40 dBr at 60 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 19.5 and 20.5 MHz, 20.5 and 40 MHz, and 40 and 60 MHz shall be linearly interpolated in dB domain from the requirements for 19.5 MHz, 20.5 MHz, 40 MHz, and 60 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectral mask and −56 dBm/MHz at any frequency offset greater than 19.5 MHz. Figure 28-46 (Example transmit spectral mask for a 40 MHz mask PPDU) shows an example of the resulting overall spectral mask when the −40 dBr spectrum level is above −56 dBm/MHz.

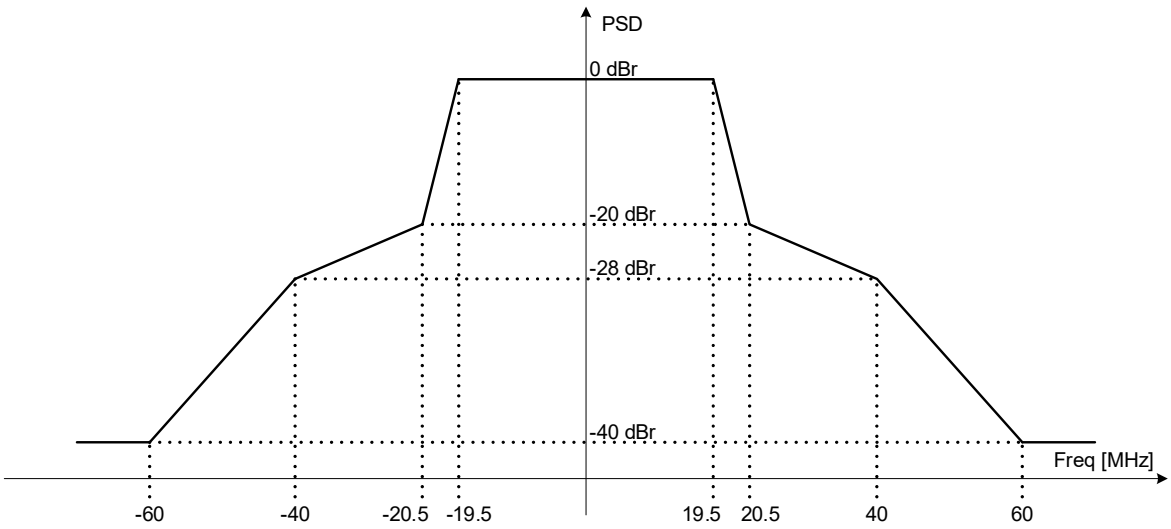


Figure 28-46—Example transmit spectral mask for a 40 MHz mask PPDU

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For an 80 MHz mask PPDU of HE format, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 79 MHz, –20 dBr at 40.5 MHz frequency offset, –28 dBr at 80 MHz frequency offset, and –40 dBr at 120 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 39.5 and 40.5 MHz, 40.5 and 80 MHz, and 80 and 120 MHz shall be linearly interpolated in dB domain from the requirements for 39.5 MHz, 40.5 MHz, 80 MHz, and 120 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectrum mask and –59 dBm/MHz at any frequency offset. Figure 28-47 (Example transmit spectral mask for an 80 MHz mask PPDU) shows an example of the resulting overall spectral mask when the –40 dBr spectrum level is above –59 dBm/MHz.

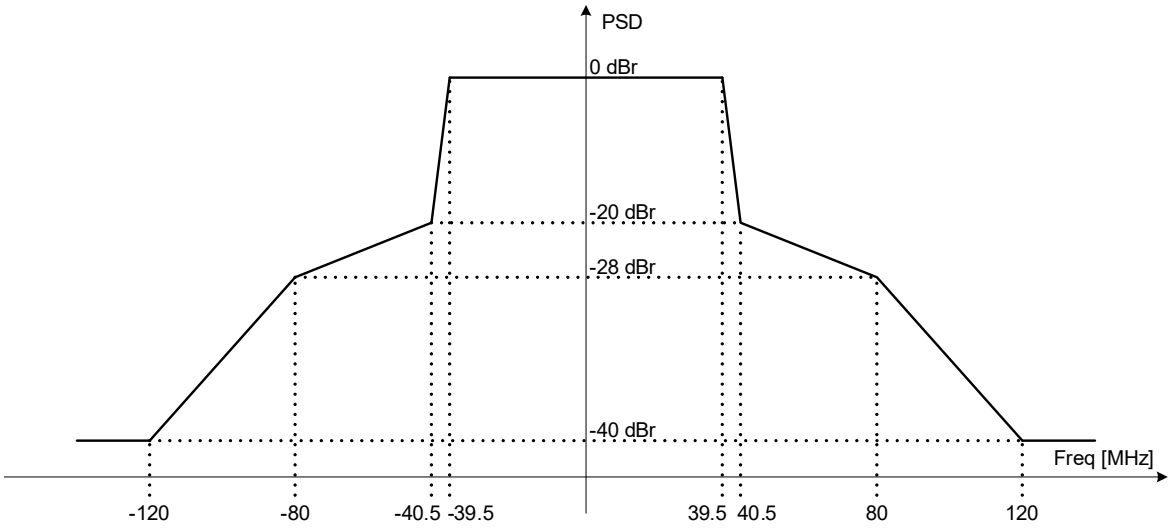


Figure 28-47—Example transmit spectral mask for an 80 MHz mask PPDU

For a 160 MHz mask PPDU of HE format, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 159 MHz, –20 dBr at 80.5 MHz frequency offset, –28 dBr at 160 MHz frequency offset, and –40 dBr at 240 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 79.5 and 80.5 MHz, 80.5 and 160 MHz, and 160 and 240 MHz shall be linearly interpolated in dB domain from the requirements for 79.5 MHz, 80.5 MHz, 160 MHz, and 240 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectrum mask and –59 dBm/MHz at any frequency offset. Figure 28-48 (Example transmit spec-

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tral mask for a 160 MHz mask PPDU) shows an example of the resulting overall spectral mask when the –40 dBr spectrum level is above –59 dBm/MHz.

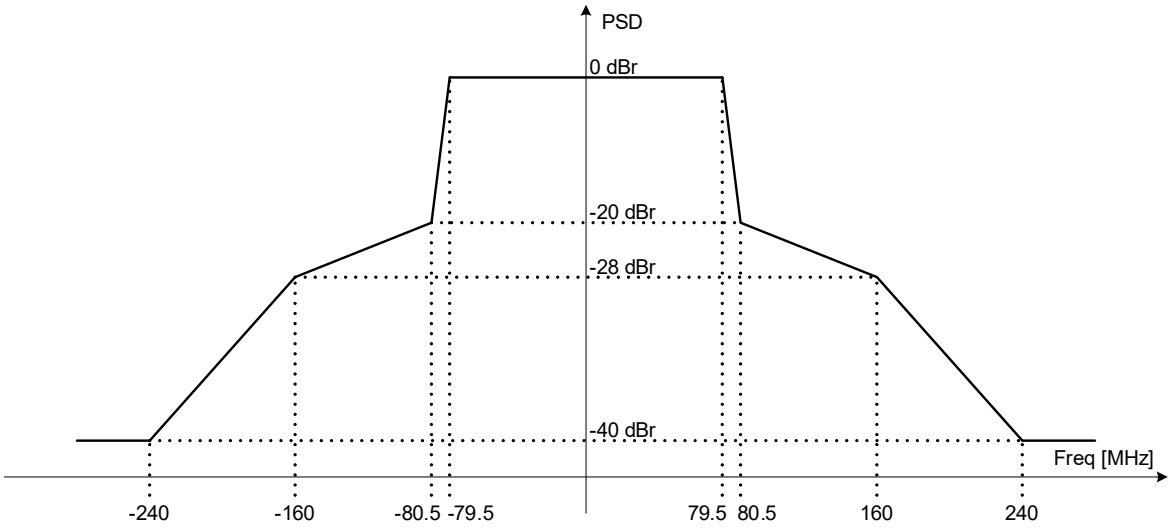


Figure 28-48—Example transmit spectral mask for a 160 MHz mask PPDU

For an 80+80 MHz mask PPDU of HE format, the overall transmit spectral mask is constructed in the following manner. First, the 80 MHz interim spectral mask is placed on each of the two 80 MHz segments. Then, for each frequency at which both of the 80 MHz interim spectral masks have values greater than –40 dBr and less than –20 dBr, the sum of the two interim mask values (summed in linear domain) shall be taken as the overall spectral mask value. Next, for each frequency at which neither of the two 80 MHz interim masks have values greater than or equal to –20 dBr and less than or equal to 0 dBr, the higher value of the two interim masks shall be taken as the overall interim spectral value. Finally, for any frequency region where the mask value has not been defined yet, linear interpolation (in dB domain) between the nearest two frequency points with the interim spectral mask value defined shall be used to define the interim spectral mask value. The transmit spectrum shall not exceed the maximum of the interim transmit spectrum mask and –59 dBm/MHz at any frequency offset. Figure 28-49 (Example transmit spectral mask for an 80+80 MHz mask PPDU) shows an example of a transmit spectral mask for a noncontiguous transmission

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using two 80 MHz channels where the center frequency of the two 80 MHz channels are separated by 160 MHz and the −40 dBr spectrum level is above −59 dBm/MHz.

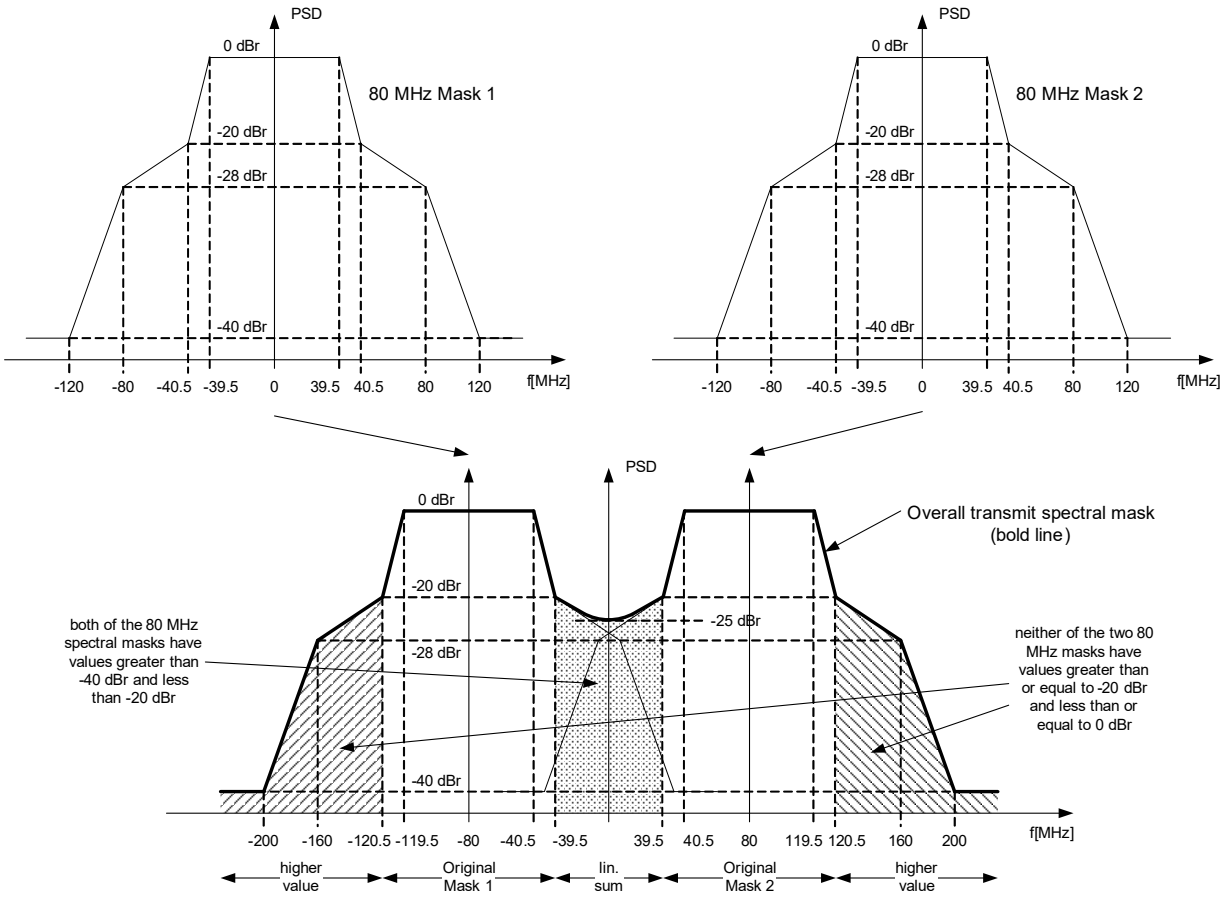


Figure 28-49—Example transmit spectral mask for an 80+80 MHz mask PPDU

Different center frequency separation between the two 80 MHz frequency segments of the spectral mask as well as different peak levels of each 80 MHz frequency segment of the spectral mask are possible, in which case a similar procedure in determining the spectral mask as in Figure 28-49 (Example transmit spectral mask for an 80+80 MHz mask PPDU) is followed.

The transmit spectral mask for noncontiguous transmissions using two nonadjacent 80 MHz channels is applicable only in regulatory domains that allow for such transmissions.

Measurements shall be made using a 100 kHz resolution bandwidth and a 7.5 kHz video bandwidth.

When preamble puncturing happens in an HE MU PPDU, the HE MU PPDU is still treated as an 80 MHz PPDU if the Bandwidth field on HE-SIG-A field of the HE MU PPDU is set to 4 or 5 or a 160 MHz or 80+80 MHz PPDU if the Bandwidth field in HE-SIG-A field of the HE MU PPDU is set to 6 or 7, therefore the spectral mask is the same as those defined for the total channel width.

28.3.18.2 Spectral flatness

Spectral flatness measurements shall be conducted using BPSK modulated HE PPDUs. The HE PPDUs shall be demodulated using the following (or equivalent) procedure:

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a) Start of PPDU shall be detected.

b) Transition from L-STF to L-LTF shall be detected and fine timing shall be established.

c) Coarse and fine frequency offsets shall be estimated.

d) Symbols in a PPDU shall be manipulated to account for both frequency error and sampling offset drift.

e) For each HE-LTF symbol, transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, and compensate the subcarrier values according to the estimated phase.

f) For each of the data OFDM symbols: transform the symbol into subcarrier received values.

The spectral flatness test shall be performed over at least 20 HE PPDUs. The PPDUs under test shall be at least 16 data OFDM symbols long.

Evaluate spectral flatness using the subcarrier received values or the magnitude of the channel estimation of the occupied subcarriers of the transmission HE PPDUs. Non-occupied subcarriers of the transmitted HE PPDUs shall be ignored during averaging and testing. Resource unit power boosting and beamforming should not be used when measuring spectral flatness.

Let $E_{i,avg}$ denote the magnitude of the channel estimation on subcarrier i or the average constellation energy of a BPSK modulated subcarrier i in an HE data symbol. In a contiguous HE transmission having a bandwidth listed in Table 28-44 (Maximum transmit spectral flatness deviations), $E_{i,avg}$ of each of the subcarriers with indices listed as tested subcarrier indices shall not deviate by more than the specified maximum deviation in Table 28-44 (Maximum transmit spectral flatness deviations) from the average of $E_{i,avg}$ over subcarrier indices listed as averaging subcarrier indices. Averaging of $E_{i,avg}$ is done in the linear domain.

Table 28-44—Maximum transmit spectral flatness deviations

Bandwidth of transmission (MHz)	Averaging subcarrier indices (inclusive)	Tested subcarrier indices (inclusive)	Maximum deviation (dB)
20	–84 to –2 and +2 to +84	–84 to –2 and +2 to +84	±4
		–122 to –85 and +85 to +122	+4/–6
40	–168 to –3 and +3 to +168	–168 to –3 and +3 to +168	±4
		–244 to –169 and +169 to +244	+4/–6
80	–344 to –3 and +3 to +344	–344 to –3 and +3 to +344	±4
		–500 to –345 and +345 to +500	+4/–6
160	–696 to –515, –509 to –166, +166 to +509, and +515 to +696	–696 to –515, –509 to –166, +166 to +509, and +515 to +696	±4
		–1012 to –697, –165 to –12, +12 to +165, and +697 to +1012	+4/–6

In an 80+80 MHz transmission, each segment shall meet the spectral flatness requirement for an 80 MHz transmission.

For the spectral flatness test, the transmitting STA shall be configured to use a spatial mapping matrix Q_k (see 28.3.11.14 (OFDM modulation)) with flat frequency response. Each output port under test of the transmitting STA shall be connected through a cable to one input port of the testing instrumentation. The require-

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ments shall apply to 20 MHz, 40 MHz, 80 MHz, and 160 MHz contiguous transmissions as well as 80+80 MHz transmissions.

28.3.18.3 Transmit center frequency and symbol clock frequency tolerance

Transmit center frequency and the symbol clock frequency for all transmit antennas and frequency segments shall be derived from the same reference oscillator. The symbol clock frequency and transmit center frequency maximum tolerance shall be ±20 ppm. HE TB PPDU format is subject to additional requirements as defined in 28.3.14 (Transmit requirements for an HE TB PPDU).

28.3.18.4 Modulation accuracy

28.3.18.4.1 Introduction to modulation accuracy tests

Transmit modulation accuracy specifications are described in 28.3.18.4.2 (Transmit center frequency leakage) and 28.3.18.4.3 (Transmitter constellation error). The test method is described in 28.3.18.4.4 (Transmitter modulation accuracy (EVM) test).

28.3.18.4.2 Transmit center frequency leakage

The TX LO leakage requirement for all transmission modes except 80+80 MHz where the RF LO falls outside both frequency segments shall be the following. The power measured at the location of the RF LO using resolution BW 78.125 kHz shall not exceed the maximum of –32 dB relative to the total transmit power and –20 dBm, or equivalently max(P–32, –20), where P is the transmit power per antenna in dBm. The transmit center frequency leakage is specified per antenna.

For an 80+80 MHz transmission where the RF LO falls outside both frequency segments, the RF LO shall meet the spectral mask requirements as defined in 28.3.18.1 (Transmit spectral mask).

28.3.18.4.3 Transmitter constellation error

The relative constellation RMS error, calculated by first averaging over subcarriers, frequency segments, HE PPDUs, and spatial streams (see Equation (28-120)) shall not exceed a data-rate dependent value according to Table 28-45 (Allowed relative constellation error versus constellation size and coding rate). The number of spatial streams under test shall be equal to the number of utilized transmitting STA antenna (output) ports and also equal to the number of utilized testing instrumentation input ports. In the test, $N_{SS} = N_{STS}$ (no STBC) shall be used. Each output port of the transmitting STA shall be connected through a cable to one input port of the testing instrumentation. The requirements shall apply to 20 MHz, 40 MHz, 80 MHz, and 160 MHz contiguous transmissions as well as 80+80 MHz noncontiguous transmissions.

Table 28-45—Allowed relative constellation error versus constellation size and coding rate

Modulation		Coding rate	Relative constellation error in an HE SU PPDU, HE extended rate SU PPDU and HE MU PPDU (dB)	Relative constellation error in an HE TB PPDU when transmit power is larger than the maximum power of MCS7 (dB)	Relative constellation error in an HE TB PPDU when transmit power is less than or equal to the maximum power of MCS7 (dB)
Without DCM	With DCM				
N/A	BPSK	1/2	–5	–13	–27
BPSK	QPSK	1/2	–5	–13	–27

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Table 28-45—Allowed relative constellation error versus constellation size and coding rate

Modulation		Coding rate	Relative constellation error in an HE SU PPDU, HE extended rate SU PPDU and HE MU PPDU (dB)	Relative constellation error in an HE TB PPDU when transmit power is larger than the maximum power of MCS7 (dB)	Relative constellation error in an HE TB PPDU when transmit power is less than or equal to the maximum power of MCS7 (dB)
Without DCM	With DCM				
QPSK	16-QAM	1/2	–10	–13	–27
QPSK	16-QAM	3/4	–13	–13	–27
16-QAM	N/A	1/2	–16	–16	–27
16-QAM	N/A	3/4	–19	–19	–27
64-QAM	N/A	2/3	–22	–22	–27
64-QAM	N/A	3/4	–25	–25	–27
64-QAM	N/A	5/6	–27	–27	–27
256-QAM	N/A	3/4	–30	–30	–30
256-QAM	N/A	5/6	–32	–32	–32
1024-QAM	N/A	3/4	–35/–32	–35/–32	–35/–32
1024-QAM	N/A	5/6	–35/–32	–35/–32	–35/–32

NOTE—The maximum power of MCS7 can be measured by setting the Target RSSI subfield as defined in Table 9-25g (Target RSSI subfield encoding) in the Trigger frame to 127 for the same data-carrying subcarriers which EVM test is conducted.

NOTE—For 1024-QAM, relative constellation error shall be equal to or less than -35 dB when amplitude drift compensation in the test equipment is on and shall be equal to or less than -32 dB when amplitude drift compensation is off in the test equipment. For all other constellations the EVM shall be equal to or less than the values in the table, no matter whether amplitude drift compensation in the test equipment is on or off.

28.3.18.4.4 Transmitter modulation accuracy (EVM) test

The transmit modulation accuracy test shall be performed by instrumentation capable of converting the transmitted signals into a stream of complex samples at sampling rate greater than or equal to the bandwidth of the signal being transmitted except that for a noncontiguous transmissions each frequency segment may be tested independently.

In this case, transmit modulation accuracy of each segment shall meet the required value in Table 28-45 (Allowed relative constellation error versus constellation size and coding rate) using only the occupied data subcarriers within the corresponding segment. For HE TB PPDU transmission, two sets of EVM requirements are defined in Table 28-45 (Allowed relative constellation error versus constellation size and coding rate) for different transmission power levels to assist AP in better managing the interference among multiple STAs responding to a Trigger frame.

LO leakage that can potentially show up in center frequency of the HE PPDU tone plan and its ±3 tone neighbors shall be excluded from the computation of the transmitter modulation accuracy test. The potential LO leakage tones for 20 MHz operating devices are the center of primary 20 MHz of the HE PPDU tone plan and ±3 tones. The potential LO leakage tones for 40 MHz operating devices are the center of the pri-

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mary 40 MHz of the PPDU tone plan and ±3 tones. The potential LO leakage tones for 80 MHz operating devices are the center of the primary 80 MHz of the PPDU tone plan and ±3 tones. The potential LO leakage tones for 160 MHz operating devices are the center of the 160 MHz of the PPDU tone plan and ±3 tones. The potential LO leakage tones for 80+80 MHz operating devices exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test. For 40 MHz capable devices that transmits 20 MHz, the potential LO leakage tones exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test. For 80 MHz capable devices that transmits 20 MHz or 40 MHz PPDU, the potential LO leakage tones exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test. For 160 or 80+80 MHz capable devices that transmits 20 MHz or 40 MHz PPDU or 80MHz PPDU, the potential LO leakage tones exist outside the PPDU bandwidth and should not affect the transmitter modulation accuracy test.

The instrument shall have sufficient accuracy in terms of I/Q branch amplitude and phase balance, DC offsets, phase noise, and analog to digital quantization noise. A possible embodiment of such a setup is converting the signals to a low IF frequency with a microwave synthesizer, sampling the signal with a digital oscilloscope and decomposing it digitally into quadrature components. The sampled signal shall be processed in a manner similar to an actual receiver, according to the following steps, or equivalent procedure:

a) Start of PPDU shall be detected.

b) Transition from L-STF to L-LTF shall be detected and fine timing shall be established.

c) Coarse and fine frequency offsets shall be estimated.

d) Symbols in a PPDU shall be derotated according to estimated frequency offset. Sampling offset drift shall be also compensated.

e) For each HE-LTF symbol, transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, and derotate the subcarrier values according to the estimated phase.

f) Estimate the complex channel response coefficient for each of the subcarriers and each of the transmit streams.

g) For each of the data OFDM symbols: transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, and compensate the subcarrier values according to the estimated phase, group the results from all of the receiver chains in each subcarrier to a vector, and multiply the vector by a zero-forcing equalization matrix generated from the estimated channel.

h) For each data-carrying subcarrier in each spatial stream of RU under test, find the closest constellation point and compute the Euclidean distance from it.

i) Compute the average across PPDUs of the RMS of all errors per PPDU as given by Equation (28-120).

$$Error_{RMS} = \frac{1}{N_f}\sum^{N_f}\sqrt{\frac{\sum_{i_s=1}^{N_{SYM}}\sum_{i_{ss}=1}^{N_{SS}}\sum_{i_{sc}=1}^{N_{SD}}\left(I_e(i_f,i_s,i_{ss},i_{sc})-I_0(i_f,i_s,i_{ss},i_{sc})\right)^2+\left(Q_e(i_f,i_s,i_{ss},i_{sc})-Q_0(i_f,i_s,i_{ss},i_{sc})\right)^2}{N_{SYM}N_{SS}N_{SD}P_0}} \quad (28\text{-}120)$$

where

$I_0(i_f, i_s, i_{ss}, i_{sc})$ $Q_0(i_f, i_s, i_{ss}, i_{sc})$ denotes the ideal symbol point in the complex plane in data tone i_{sc} of the RU under test, spatial stream i_{ss}, and OFDM symbol i_s of frame i_f.

$I_e(i_f, i_s, i_{ss}, i_{sc})$ $Q_e(i_f, i_s, i_{ss}, i_{sc})$ denotes the equalized observed symbol point in the complex plane of the i_{sc}-th data tone of the RU under test, spatial stream i_{ss}, and OFDM symbol i_s of frame i_f.

P_0 is the average power of constellation

N_f is the number of tested frames

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N_{SD} is the number of data tones of the occupied RU

N_{SS} is the number of spatial streams of the data

N_{SYM} is the number of data OFDM symbols

NOTE 1—In the case the transmit modulation accuracy test is performed simultaneously for the two frequency segments of the 80+80 MHz transmissions with 2×996-subcarrier RU.

The test shall be performed over at least 20 PPDUs (N_f as defined in Equation (28-120)). When the occupied RU has 26 tones, the PPDUs under test shall be at least 32 data OFDM symbols long. For occupied RUs that have more than 26 tones, the PPDUs under test shall be at least 16 data OFDM symbols long. Random data shall be used for the symbols.

For an HE TB PPDU, additional transmit modulation accuracy test for the unoccupied subcarriers of the PPDU shall be performed. The transmit modulation accuracy of unoccupied subcarriers of the PPDU test shall be performed by instrumentation capable of converting the transmitted signals into a stream of complex samples at sampling rate greater than or equal to the bandwidth of the signal being transmitted except that for noncontiguous transmissions, only the frequency segment with occupied subcarriers is tested. The transmit modulation accuracy of unoccupied subcarriers of the PPDU shall meet the relative constellation error staircase mask for each modulation and code rate using the unoccupied subcarriers within the corresponding segment.

The instrument shall have sufficient accuracy in terms of I/Q branch amplitude and phase balance, DC offsets, phase noise, and analog to digital quantization noise. A possible embodiment of such a setup is converting the signals to a low IF frequency with a microwave synthesizer, sampling the signal with a digital oscilloscope and decomposing it digitally into quadrature components. The sampled signal shall be processed in a manner similar to an actual receiver, according to the following steps, or equivalent procedure:

a) Start of PPDU shall be detected.

b) Transition from L-STF to L-LTF shall be detected and fine timing shall be established.

c) Coarse and fine frequency offsets shall be estimated.

d) Symbols in a PPDU shall be derotated according to estimated frequency offset. Sampling offset drift shall be also compensated.

e) For each of the data OFDM symbols, transform the symbol into subcarrier received values and estimate the power of each subcarrier.

f) Compute the average unoccupied subcarrier error vector magnitude for each unoccupied 26-tone RU and average across PPDUs of the RMS of all errors per PPDU as given by Equation (28-121).

$$UnusedToneError_{RMS}(k) = \frac{1}{N_f}\sum_{i_f=1}^{N_f}\sqrt{\frac{\sum_{i_s}\sum_{i_{RU}\in\Omega_k}(I_u(i_f,i_s,i_{RU}))^2+(Q_u(i_f,i_s,i_{RU}))^2}{N_{SYM}\cdot 26\cdot P_S}} \quad (28\text{-}121)$$

where

$I_u(i_f, i_s, i_{RU})$ $Q_u(i_f, i_s, i_{RU})$ denotes unequalized observed symbol point in the complex plane in unoccupied 26-tone RU i_{RU} and OFDM symbol is of frame i_f.

Ω_k is a set of subcarriers for k-th 26-tone RU as defined in Table 28-6 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU), Table 28-7 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU) and Table 28-8 (Data and pilot subcarrier indices for RUs in an 80 MHz HE PPDU)

P_S is the average data subcarrier power of the occupied RU under test and is given by Equation (28-122)

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$$P_S = \frac{1}{N_{SYM} N_{ST}} \sum_{i_s = 1}^{N_{SYM}} \sum_{i_{sc} = 1}^{N_{SD}} (I_u(i_f, i_s, i_{SC}))^2 + (Q_u(i_f, i_s, i_{SC}))^2 \quad (28\text{-}122)$$

N_f is the number of tested frames

N_{SYM} is the number of data OFDM symbols

N_{SD} is the number of data tones of the occupied RU

g) For all MCS, for an occupied RU bandwidth of r in units of a 26-tone RU as defined by Equation (28-123)

$$r = \begin{cases} 1, \text{ if 26-tone RU} \\ 2, \text{ if 52-tone RU} \\ 4, \text{ if 106-tone RU} \\ 9, \text{ if 242-tone RU} \\ 18, \text{ if 484-tone RU} \\ 37, \text{ if 996-tone RU} \end{cases} \quad (28\text{-}123)$$

the average unoccupied subcarrier error vector magnitude for each unoccupied 26-tone RU as calculated in step f) shall meet the staircase mask requirement in Equation (28-124).

$$UnusedToneError_{RMS}(m) \leq \begin{cases} \max(UsedToneError_{RMS} - 2, -35 \text{ dB}), & 1 \leq m \leq r \\ \max(UsedToneError_{RMS} - 12, -35 \text{ dB}), & r + 1 \leq m \leq 2r \\ \max(UsedToneError_{RMS} - 22, -35 \text{ dB}), & 2r + 1 \leq m \leq 3r \\ -35 \text{ dB, otherwise} \end{cases} \quad (28\text{-}124)$$

where

m defines the gap in the units of 26-tone RU to the occupied RU from either side and is a positive integer with $m = 1$ being the adjacent 26-tone RU

$UsedToneError_{RMS}$ is the relative constellation error for an HE TB PPDU defined in Table 28-45 (Allowed relative constellation error versus constellation size and coding rate)

The test shall be performed over at least 20 PPDUs (N_f as defined in Equation (28-120)). The PPDUs under test shall be at least 16 data OFDM symbols long. The unequalized observed symbol of potential LO leakage subcarrier locations shall be treated as zero during unoccupied subcarriers transmit modulation accuracy test. Random data shall be used for the symbols.

28.3.18.5 Time of Departure accuracy

The Time of Departure accuracy test evaluates TIME_OF_DEPARTURE against aTxPHYTxStartRMS and aTxPHYTxStartRMS against TIME_OF_DEPARTURE_ACCURACY_TEST_THRESH as defined in Annex P with the following test parameters:

— MULTICHANNEL_SAMPLING_RATE is:

$20 \times 10^6 \left(1 + \left\lceil \frac{f_H - f_L}{20 \text{ MHz}} \right\rceil\right)$ sample/s, for a CH_BANDWIDTH parameter equal to CBW20

$40 \times 10^6 \left(1 + \left\lceil \frac{f_H - f_L}{40 \text{ MHz}} \right\rceil\right)$ sample/s, for a CH_BANDWIDTH parameter equal to CBW40

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$80 \times 10^6\left(1 + \left\lceil \frac{f_H - f_L}{80\ \text{MHz}} \right\rceil\right)$ sample/s, for a CH_BANDWIDTH parameter equal to CBW80

$160 \times 10^6\left(1 + \left\lceil \frac{f_H - f_L}{160\ \text{MHz}} \right\rceil\right)$ sample/s, for a CH_BANDWIDTH parameter equal to CBW160 or CBW80+80

where

f_H is the nominal center frequency in Hz of the highest channel in the channel set

f_L is the nominal center frequency in Hz of the lowest channel in the channel set, the channel set is the set of channels upon which frames providing measurements are transmitted, the channel set comprises channels uniformly spaced across.

— FIRST_TRANSITION_FIELD is L-STF.

— SECOND_TRANSITION_FIELD is L-LTF.

— TRAINING_FIELD is L-LTF windowed in a manner which should approximate the windowing described in 17.3.2.5 (Mathematical conventions in the signal descriptions) with TTR = 100 ns.

— TIME_OF_DEPARTURE_ACCURACY_TEST_THRESH is 80 ns.

NOTE—The indicated windowing applies to the time of departure accuracy test equipment, and not the transmitter or receiver.

28.3.19 Receiver specification

28.3.19.1 General

For tests in this subclause, the input levels are measured at the antenna connectors and are referenced as the average power per receive antenna. The number of spatial streams under test shall be equal to the number of utilized transmitting STA antenna (output) ports and also equal to the number of utilized Device Under Test input ports. Each output port of the transmitting STA shall be connected through a cable to one input port of the Device Under Test.

28.3.19.2 Receiver minimum input sensitivity

The packet error rate (PER) shall be less than 10% for a PSDU with the rate-dependent input levels listed in Table 28-46 (Receiver minimum input level sensitivity). The PSDU length shall be 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. The test in this subclause and the minimum sensitivity levels specified in Table 28-46 (Receiver minimum input level sensitivity) apply only to non-STBC modes, 800 ns GI, BCC for 20 MHz bandwidth and LDPC for bandwidth greater than 20 MHz, and HE SU PPDUs.

Table 28-46—Receiver minimum input level sensitivity

Modulation		Rate (R)	Minimum sensitivity (20 MHz PPDU) (dBm)	Minimum sensitivity (40 MHz PPDU) (dBm)	Minimum sensitivity (80 MHz PPDU) (dBm)	Minimum sensitivity (160 MHz or 80+80 MHz PPDU) (dBm)
Without DCM	With DCM					
N/A	BPSK	1/2	–82	–79	–76	–73
BPSK	QPSK	1/2	–82	–79	–76	–73
QPSK	16-QAM	1/2	–79	–76	–73	–70
QPSK	16-QAM	3/4	–77	–74	–71	–68

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Table 28-46—Receiver minimum input level sensitivity

Modulation		Rate (R)	Minimum sensitivity (20 MHz PPDU) (dBm)	Minimum sensitivity (40 MHz PPDU) (dBm)	Minimum sensitivity (80 MHz PPDU) (dBm)	Minimum sensitivity (160 MHz or 80+80 MHz PPDU) (dBm)
Without DCM	With DCM					
16-QAM	N/A	1/2	–74	–71	–68	–65
16-QAM	N/A	3/4	–70	–67	–64	–61
64-QAM	N/A	2/3	–66	–63	–60	–57
64-QAM	N/A	3/4	–65	–62	–59	–56
64-QAM	N/A	5/6	–64	–61	–58	–55
256-QAM	N/A	3/4	–59	–56	–53	–50
256-QAM	N/A	5/6	–57	–54	–51	–48
1024-QAM	N/A	3/4	–54	–51	–48	–45
1024-QAM	N/A	5/6	–52	–49	–46	–43

28.3.19.3 Adjacent channel rejection

Adjacent channel rejection for W MHz (where W is 20, 40, 80, or 160) shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 28-46 (Receiver minimum input level sensitivity) and raising the power of the interfering signal of W MHz bandwidth until 10% PER is caused for a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. The difference in power between the signals in the interfering channel and the desired channel is the corresponding adjacent channel rejection. The center frequency of the adjacent channel shall be placed W MHz away from the center frequency of the desired signal.

Adjacent channel rejection for 80+80 MHz channels shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 28-46 (Receiver minimum input level sensitivity). Then, an interfering signal of 80 MHz bandwidth is introduced, where the center frequency of the interfering signal is placed 80 MHz away from the center frequency of the frequency segment lower in the frequency of the desired signal. The power of interfering signal is raised until 10% PER is caused for a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. Let ΔP_1 be the difference between the interfering and desired signal. Next, the interfering signal of 80 MHz bandwidth is moved to the frequency where the center frequency of the interfering signal is 80 MHz away from the center frequency of the frequency segment higher in frequency of the desired signal. The power of the interfering is raised until 10% PER is caused for a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. Let ΔP_2 be the power difference between the interfering and desired signal. The smaller value between ΔP_1 and ΔP_2 is the corresponding adjacent channel rejection.

The interfering signal in the adjacent channel shall be a signal compliant with the HE PHY, unsynchronized with the signal in the channel under test, and shall have a minimum duty cycle of 50%. The corresponding rejection shall be no less than specified in Table 28-47 (Minimum required adjacent and nonadjacent channel rejection levels).

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The test in this subclause and the adjacent sensitivity levels specified in Table 28-47 (Minimum required adjacent and nonadjacent channel rejection levels) apply only to non-STBC modes, 800 ns GI, BCC for 20 MHz bandwidth and LDPC for greater than 20 MHz bandwidth, and HE SU PPDUs.

Table 28-47—Minimum required adjacent and nonadjacent channel rejection levels

Modulation		Rate (R)	Adjacent channel rejection (dB)		Nonadjacent channel rejection (dB)	
Without DCM	With DCM		20/40/80/ 160 MHz Channel	80+80 MHz Channel	20/40/80/ 160 MHz Channel	80+80 MHz Channel
N/A	BPSK	1/2	16	13	32	29
BPSK	QPSK	1/2	16	13	32	29
QPSK	16-QAM	1/2	13	10	29	26
QPSK	16-QAM	3/4	11	8	27	24
16-QAM	N/A	1/2	8	5	24	21
16-QAM	N/A	3/4	4	1	20	17
64-QAM	N/A	2/3	0	–3	16	13
64-QAM	N/A	3/4	–1	–4	15	12
64-QAM	N/A	5/6	–2	–5	14	11
256-QAM	N/A	3/4	–7	–10	9	6
256-QAM	N/A	5/6	–9	–12	7	4
1024-QAM	N/A	3/4	–12	–15	4	1
1024-QAM	N/A	5/6	–14	–17	2	–1

The measurement of adjacent channel rejection for 160 MHz operation in regulatory domain is required only if such a frequency band plan is permitted in the regulatory domain.

28.3.19.4 Nonadjacent channel rejection

Nonadjacent channel rejection for W MHz channels (where W is 20, 40, 80, or 160) shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 28-46 (Receiver minimum input level sensitivity), and raising the power of the interfering signal of W MHz bandwidth until a 10% PER occurs for a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. The difference in power between the signals in the interfering channel and the desired channel is the corresponding nonadjacent channel rejection. The nonadjacent channel rejection shall be met with any nonadjacent channels located at least $2\times W$ MHz away from the center frequency of the desired signal.

Nonadjacent channel rejection for 80+80 MHz channels shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 28-46 (Receiver minimum input level sensitivity). Then, an interfering signal of 80 MHz bandwidth is introduced, where the center frequency of the interfering signal is placed at least 160 MHz away from the center frequency of the frequency segment lower in the frequency of the desired signal. The center frequency of the interfering signal shall also be at least 160 MHz away from the center frequency of the frequency segment higher in frequency of the desired

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signal. The power of interfering signal is raised until 10% PER is caused for a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. Let ΔP_1 be the difference between the interfering and desired signal. Next, the interfering signal of 80 MHz bandwidth is moved to the frequency where the center frequency of the interfering signal is at least 160 MHz away from the center frequency of the frequency segment higher in frequency of the desired signal. The center frequency of the interfering signal shall also be at least 160 MHz away from the center frequency of the frequency segment lower in frequency of the desired signal. The power of the interfering is raised until 10% PER is caused for a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations. Let ΔP_2 be the power difference between the interfering and desired signal. The smaller value between ΔP_1 and ΔP_2 is the corresponding nonadjacent channel rejection.

The interfering signal in the nonadjacent channel shall be a signal compliant with the HE PHY, unsynchronized with the signal in the channel under test, and shall have a minimum duty cycle of 50%. The corresponding rejection shall be no less than specified in Table 28-47 (Minimum required adjacent and nonadjacent channel rejection levels).

The test in this subclause and the nonadjacent sensitivity levels specified in Table 28-47 (Minimum required adjacent and nonadjacent channel rejection levels) apply only to non-STBC modes, 800 ns GI, BCC for 20 MHz bandwidth and LDPC for greater than 20 MHz bandwidth, and HE SU PPDUs.

The measurement of nonadjacent channel rejection for 160 MHz operation in regulatory domain is required only if such a frequency band plan is permitted in the regulatory domain.

28.3.19.5 Receiver maximum input level

The receiver shall provide a maximum PER of 10% at a PSDU length of 2048 octets for BPSK modulation with DCM or 4096 octets for all other modulations, for a maximum input level of −30 dBm in 5 GHz band and −20 dBm in 2.4 GHz band, measured at each antenna for any baseband HE modulation.

28.3.19.6 CCA sensitivity

28.3.19.6.1 General

The thresholds in this subclause are compared with the signal level at each receiving antenna.

28.3.19.6.2 CCA sensitivity for operating classes requiring CCA-ED

For the operating classes requiring CCA-Energy Detect (CCA-ED), the PHY shall indicate a medium busy condition when CCA-ED detects a channel busy condition. For improved spectrum sharing, CCA-ED is required in some bands. The behavior class indicating CCA-ED is given in Table D-2 (Behavior limits). The operating classes requiring the corresponding CCA-ED behavior class are given in E.1 (Country information and operating classes). The PHY of a STA that is operating within an operating class that requires CCA-ED shall operate with CCA-ED.

CCA-ED for a STA that is attempting a non-preamble puncturing transmission shall detect a channel busy condition when the received signal strength exceeds the CCA-ED threshold as given by dot11OFDMEDThreshold for the primary 20 MHz channel, dot11OFDMEDThreshold for the secondary 20 MHz channel (if present), dot11OFDMEDThreshold + 3 dB for the secondary 40 MHz channel (if present), and dot11OFDMEDThreshold + 6 dB for the secondary 80 MHz channel (if present). The CCA-ED thresholds for the operating classes requiring CCA-ED are subject to the criteria in D.2.5 (CCA-ED threshold).

CCA-ED for a STA that is attempting a preamble puncturing transmission shall detect a channel busy condition when the received signal strength exceeds the CCA-ED threshold as given by dot11OFDMEDThreshold for the primary 20 MHz channel and dot11OFDMEDThreshold for each non-primary 20 MHz

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subchannel. The CCA-ED thresholds for the operating classes requiring CCA-ED are subject to the criteria in D.2.5 (CCA-ED threshold).

For the HE TB PPDU transmission, for each of 20 MHz sub-channels that require CCA, CCA-ED shall detect a channel busy condition when the received signal strength exceeds the CCA-ED threshold as given by dot11OFDMEDThreshold. The CCA-ED thresholds for the operating classes requiring CCA-ED are subject to the criteria in D.2.5 (CCA-ED threshold).

For a BQR transmission, CCA-ED shall detect a channel busy condition when the received signal strength exceeds the CCA-ED threshold as given by dot11OFDMEDThreshold for primary 20 MHz channel and dot11OFDMEDThreshold for the non-primary 20 MHz channel (if present). The CCA-ED thresholds for the operating classes requiring CCA-ED are subject to the criteria in D.2.5 (CCA-ED threshold).

NOTE—The requirement to detect a channel busy condition as stated in 28.3.19.6.3 (CCA sensitivity for the primary 20 MHz channel) and 28.3.19.6.4 (CCA sensitivity for signals not occupying the primary 20 MHz channel) is a mandatory energy detect requirement on all Clause 28 (High Efficiency (HE) PHY specification) receivers. Support for CCA-ED is an additional requirement that relates specifically to the sensitivities described in D.2.5 (CCA-ED threshold).

28.3.19.6.3 CCA sensitivity for the primary 20 MHz channel

When the dot11HECCAIndicationMode is equal to either 0 (singleelement) or 1 (per20bitmap), the PHY shall issue a PHY-CCA.indication(BUSY, {primary}) primitive if one of the conditions listed in Table 28-48 (Conditions for CCA BUSY on the primary 20 MHz) is met in an otherwise idle 20 MHz, 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz operating channel width. With >90% probability, the PHY shall detect the start of a PPDU that occupies at least the primary 20 MHz channel under the conditions listed in Table 28-48 (Conditions for CCA BUSY on the primary 20 MHz) within a period of aCCATime (see 21.4.4 (VHT PHY)) and hold the CCA signal busy (PHY-CCA.indication(BUSY, channel-list) primitive) for the duration of the PPDU, unless it receives a CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 27.9 (Spatial reuse operation).

Table 28-48—Conditions for CCA BUSY on the primary 20 MHz

Operating Channel Width	Conditions
20 MHz, 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz	The start of a 20 MHz NON_HT PPDU in the primary 20 MHz channel as defined in 17.3.10.6 (CCA requirements). The start of an HT PPDU under the conditions defined in 19.3.19.5 (CCA sensitivity). The start of a 20 MHz VHT PPDU in the primary 20 MHz channel at or above –82 dBm. The start of a 20 MHz HE PPDU in the primary 20 MHz channel at or above –82 dBm.
40 MHz, 80 MHz, 160 MHz, or 80+80 MHz	The start of a 40 MHz non-HT duplicate, VHT PPDU or HE PPDU in the primary 40 MHz channel at or above –79 dBm. The start of an HT PPDU under the conditions defined in 19.3.19.5 (CCA sensitivity).
80 MHz, 160 MHz, or 80+80 MHz	The start of an 80 MHz non-HT duplicate, VHT PPDU or HE PPDU in the primary 80 MHz channel at or above –76 dBm.
160 MHz or 80+80 MHz	The start of a 160 MHz or 80+80 MHz non-HT duplicate, VHT PPDU or HE PPDU at or above –73 dBm.

When the dot11HECCAIndicationMode is equal to either 0 (singleelement) or 1 (per20bitmap), the receiver shall issue a PHY-CCA.indication(BUSY, {primary}) primitive for any signal that exceeds a threshold equal to 20 dB above the minimum modulation and coding rate sensitivity (–82 + 20 = –62 dBm) in the pri-

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mary 20 MHz channel within a period of aCCATime after the signal arrives at the receiver's antenna(s); then the receiver shall not issue a PHY-CCA.indication(BUSY,{secondary}), PHYCCA.indication(BUSY,{secondary40}), PHY-CCA.indication(BUSY,{secondary80}), or PHYCCA.indication(IDLE) primitive while the threshold continues to be exceeded.

28.3.19.6.4 CCA sensitivity for signals not occupying the primary 20 MHz channel

When the dot11HECCAIndicationMode is equal to 0 (singleelement), the PHY shall issue a PHY-CCA.indication(BUSY, {secondary}) primitive if the conditions for issuing PHY-CCA.indication(BUSY, {primary}) primitive are not present and one of the following conditions are present in an otherwise idle 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz operating channel width:

— Any signal within the secondary 20 MHz channel at or above a threshold of –62 dBm within a period of aCCATime after the signal arrives at the receiver's antenna(s); then the PHY shall not issue a PHY-CCA.indication(BUSY, {secondary40}), PHY-CCA.indication(BUSY, {secondary80}), or PHY-CCA.indication(IDLE) primitive while the threshold continues to be exceeded.

— A 20 MHz NON_HT, HT_MF, HT_GF, VHT PPDU or HE PPDU detected in the secondary 20 MHz channel at or above max(–72 dBm, $OBSS\_PD_{level}$) with >90% probability within a period aCCAMidTime (see 28.4.4 (HE PHY)).

When the dot11HECCAIndicationMode is equal to 0 (singleelement), the PHY shall issue a PHY-CCA.indication(BUSY, {secondary40}) primitive if the conditions for issuing a PHY-CCA.indication(BUSY, {primary}) and PHY-CCA.indication(BUSY, {secondary}) primitive are not present and one of the following conditions are present in an otherwise idle 80 MHz, 160 MHz, or 80+80 MHz operating channel width:

— Any signal within the secondary 40 MHz channel at or above a threshold of –59 dBm within a period of aCCATime after the signal arrives at the receiver's antenna(s); then the PHY shall not issue a PHY-CCA.indication(BUSY, {secondary80}) primitive or PHY-CCA.indication(IDLE) primitive while the threshold continues to be exceeded.

— A 40 MHz non-HT duplicate, HT_MF, HT_GF, VHT PPDU or HE PPDU detected in the secondary 40 MHz channel at or above max(–72 dBm, $OBSS\_PD_{level(40\ MHz)}$) with >90% probability within a period aCCAMidTime (see 28.4.4 (HE PHY)).

— A 20 MHz non-HT, HT_MF, HT_GF, VHT PPDU or HE PPDU detected in any 20 MHz sub-channel of the secondary 40 MHz channel at or above max(–72 dBm, $OBSS\_PD_{level}$) with >90% probability within a period aCCAMidTime.

When the dot11HECCAIndicationMode is equal to 0 (singleelement), the PHY shall issue a PHY-CCA.indication(BUSY, {secondary80}) primitive if the conditions for PHYCCA.indication(BUSY, {primary}), PHY-CCA.indication(BUSY, {secondary}), and PHYCCA.indication(BUSY, {secondary40}) primitive are not present and one of the following conditions are present in an otherwise idle 160 MHz or 80+80 MHz operating channel width:

— Any signal within the secondary 80 MHz channel at or above –56 dBm.

— An 80 MHz non-HT duplicate, VHT PPDU or HE PPDU detected in the secondary 80 MHz channel at or above max(–69 dBm, $OBSS\_PD_{level(80\ MHz)}$) with >90% probability within a period aCCAMidTime (see 28.4.4 (HE PHY)).

— A 40 MHz non-HT duplicate, HT_MF, HT_GF, VHT or HE PPDU detected in any 40 MHz sub-channel of the secondary 80 MHz channel at or above max(–72 dBm, $OBSS\_PD_{level(40\ MHz)}$) with >90% probability within a period aCCAMidTime.

— A 20 MHz NON_HT, HT_MF, HT_GF, VHT or HE PPDU detected in any 20 MHz sub-channel of the secondary 80 MHz channel at or above max(–72 dBm, $OBSS\_PD_{level}$) with >90% probability within a period aCCAMidTime.

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$OBSS\_PD_{level}$, *$OBSS\_PD_{level}$(40 MHz)* and *$OBSS\_PD_{level}$(80 MHz)* are define in 27.9.2.2 (Adjustment of OBSS_PD and transmit power).

28.3.19.6.5 Per 20 MHz CCA sensitivity

When the dot11HECCAIndicationMode is equal to 1 (per20bitmap), the PHY shall issue a PHY-CCA.indication(BUSY, {per20MHzbitmap}) primitive if the conditions for issuing PHY-CCA.indication(BUSY, {primary}) primitive are not present and one of the following conditions are present in an otherwise idle 80 MHz, 160 MHz, or 80+80 MHz operating channel width:

— Any signal within the any 20 MHz subchannel of secondary 20 MHz, secondary 40 MHz or secondary 80 MHz at or above a threshold of –62 dBm within a period of aCCATime after the signal arrives at the receiver's antenna(s); then the PHY shall not issue PHY-CCA.indication(IDLE) primitive while the threshold continues to be exceeded.

— An 80 MHz non-HT duplicate, VHT PPDU or HE PPDU detected in the secondary 80 MHz channel at or above max(–69 dBm, *$OBSS\_PD_{level}$(80 MHz)*) with > 90% probability within a period aCCAMidTime (see 28.4.3 (HE PHY)).

— A 40 MHz non-HT duplicate, HT_MF, HT_GF, VHT or HE PPDU detected in any 40 MHz subchannel of the secondary 80 MHz channel at or above max(–72 dBm, *$OBSS\_PD_{level}$(40 MHz)*) with > 90% probability within a period aCCAMidTime.

— A 20 MHz NON_HT, HT_MF, HT_GF, VHT, or HE PPDU detected in the any 20 MHz subchannel of secondary 20 MHz, secondary 40 MHz or secondary 80 MHz at or above max(–72 dBm, *$OBSS\_PD_{level}$*) with >90% probability within a period aCCAMidTime (see 28.4.4 (HE PHY)).

When the dot11HECCAIndicationMode is equal to 2 (per20bitmapsifs), the PHY shall issue a PHY-CCA.indication(BUSY, {per20MHzbitmap}) primitive if one of the following conditions are present in an otherwise idle 20 MHz, 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz operating channel width:

— Any signal within any 20 MHz subchannel of primary 20 MHz, secondary 20 MHz, secondary 40 MHz or secondary 80 MHz at or above a threshold of –62 dBm within a period of aCCATime after the signal arrives at the receiver's antenna(s); then the PHY shall not issue PHY-CCA.indication(IDLE) primitive while the threshold continues to be exceeded.

The per20MHzbitmap is 8 bits in length. For 160 MHz or 80+80 MHz operation, the first bit to the 8th bit correspond to the 20 MHz subchannel with the lowest frequency to the 20 MHz subchannel with the highest frequency respectively. When a 20 MHz subchannel is BUSY, the corresponding bit is set to 1, otherwise it is set to 0. When the dot11HECCAIndicationMode is equal to 1 (per20bitmap), the bit corresponding to the primary 20 MHz is set to 0.

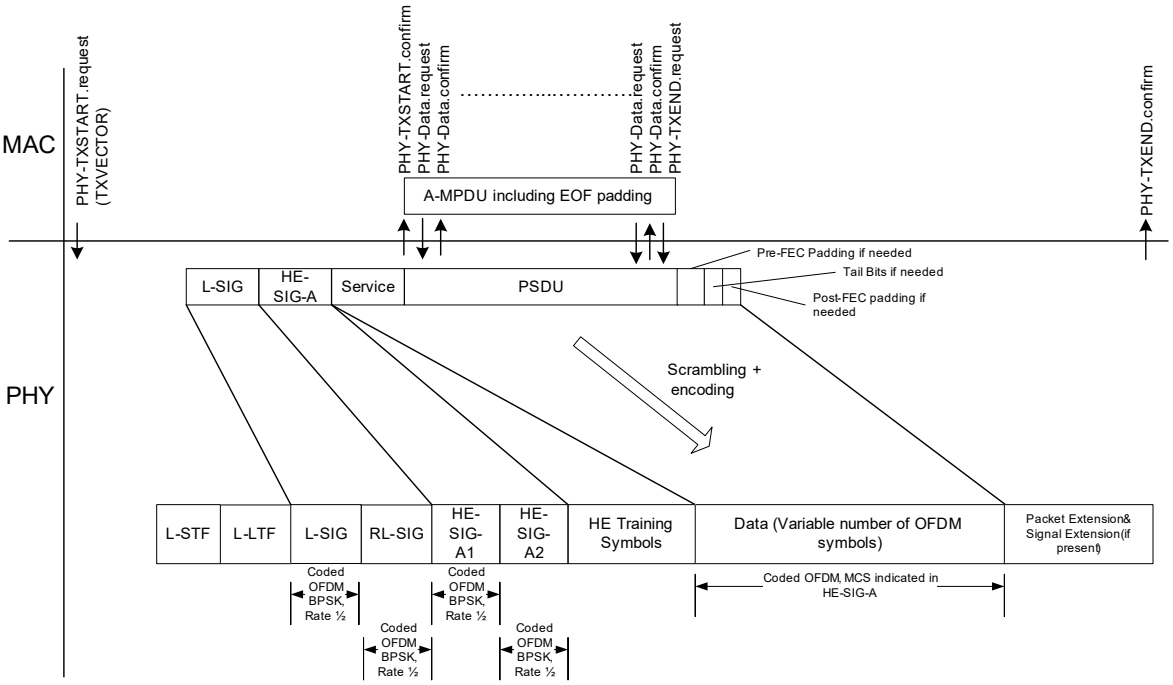
For 80 MHz operation, the first bit to the 4th bit corresponds to the 20 MHz subchannel with the lowest frequency to the 20 MHz subchannel with the highest frequency respectively. When a 20 MHz subchannel is BUSY, the corresponding bit is set to 1, otherwise it is set to 0. When the dot11HECCAIndicationMode is equal to 1 (per20bitmap), the bit corresponding to the primary 20 MHz is set to 0 and the last 4 bits are reserved and set to 1s.

28.3.20 HE transmit procedure

There are five options for the transmit PHY procedure. The first four options, for which typical transmit procedures are shown in Figure 28-50 (PHY transmit procedure for an HE SU PPDU), Figure 28-51 (PHY transmit procedure for an HE ER SU PPDU), Figure 28-52 (PHY transmit procedure for an HE MU PPDU) and Figure 28-53 (PHY transmit procedure for an HE TB PPDU), are selected if the FORMAT field of the PHY-TXSTART.request(TXVECTOR) primitive is equal to HE_SU, HE_MU, HE_EXT_SU, or

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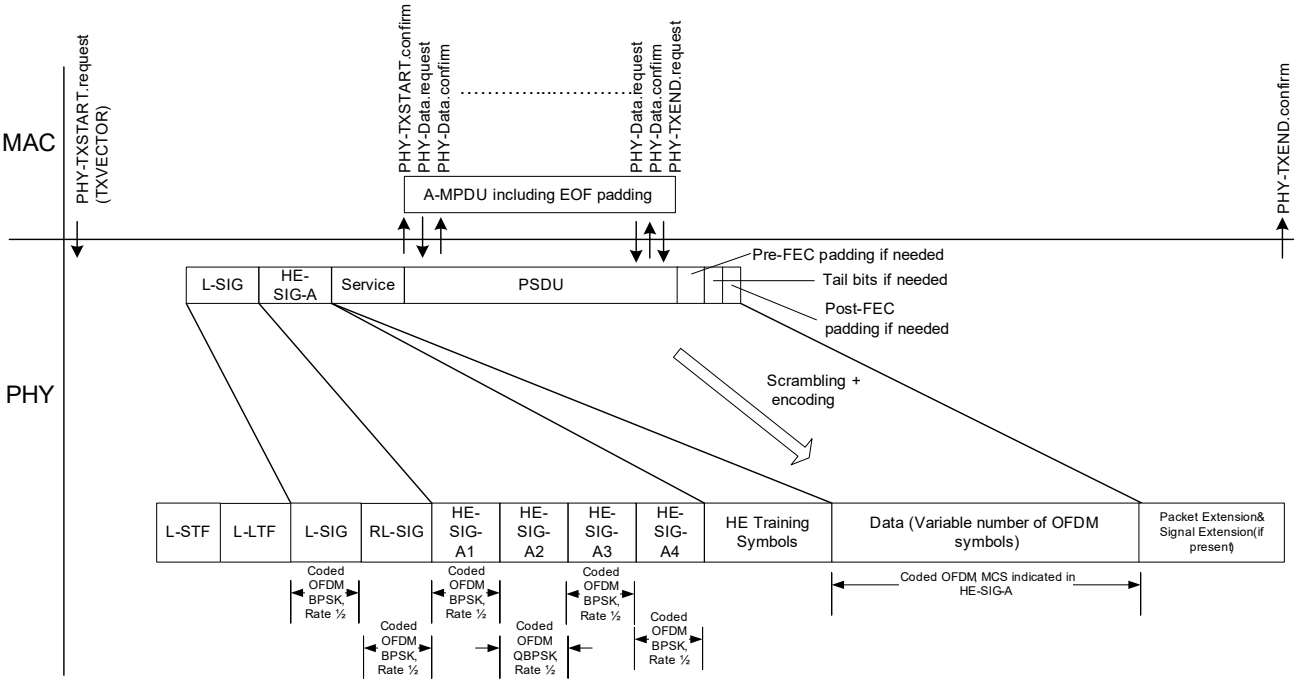
HT_TRIG, respectively. These transmit procedures do not describe the operation of optional features, such as DCM.



NOTE—This procedure does not describe the operation of optional features , such as DCM.

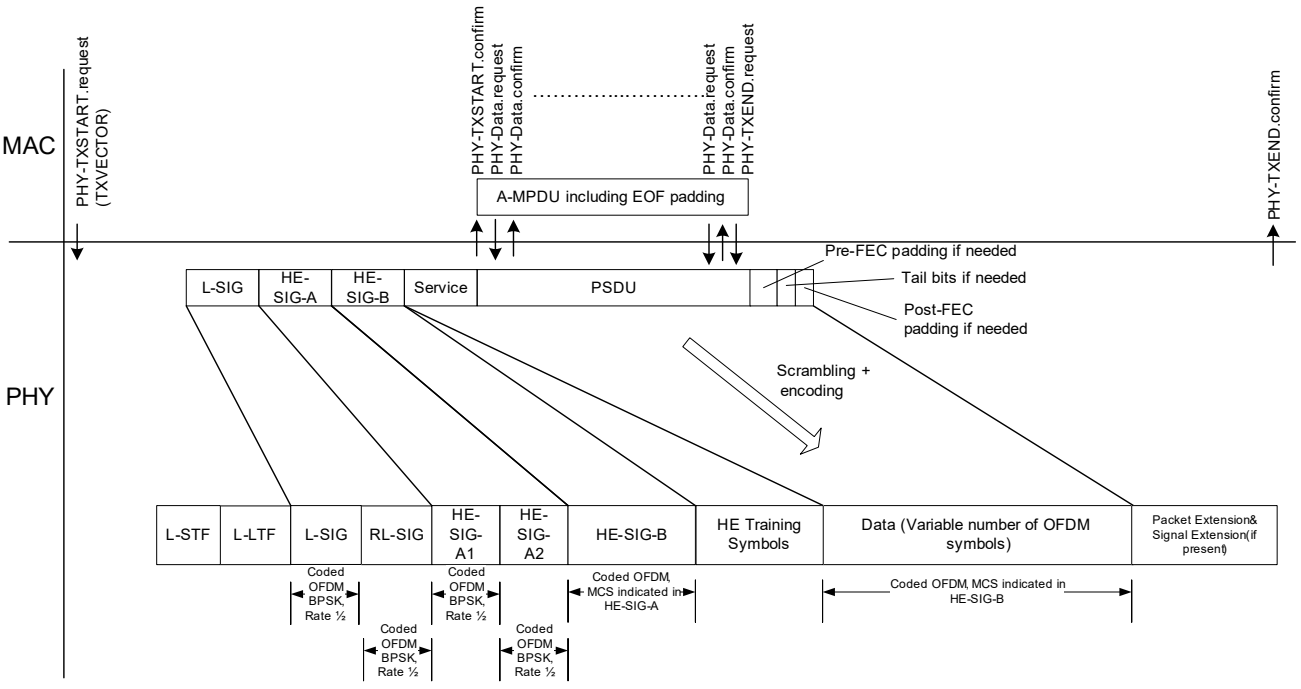
Figure 28-50—PHY transmit procedure for an HE SU PPDU

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NOTE—This procedure does not describe the operation of optional features , such as DCM.

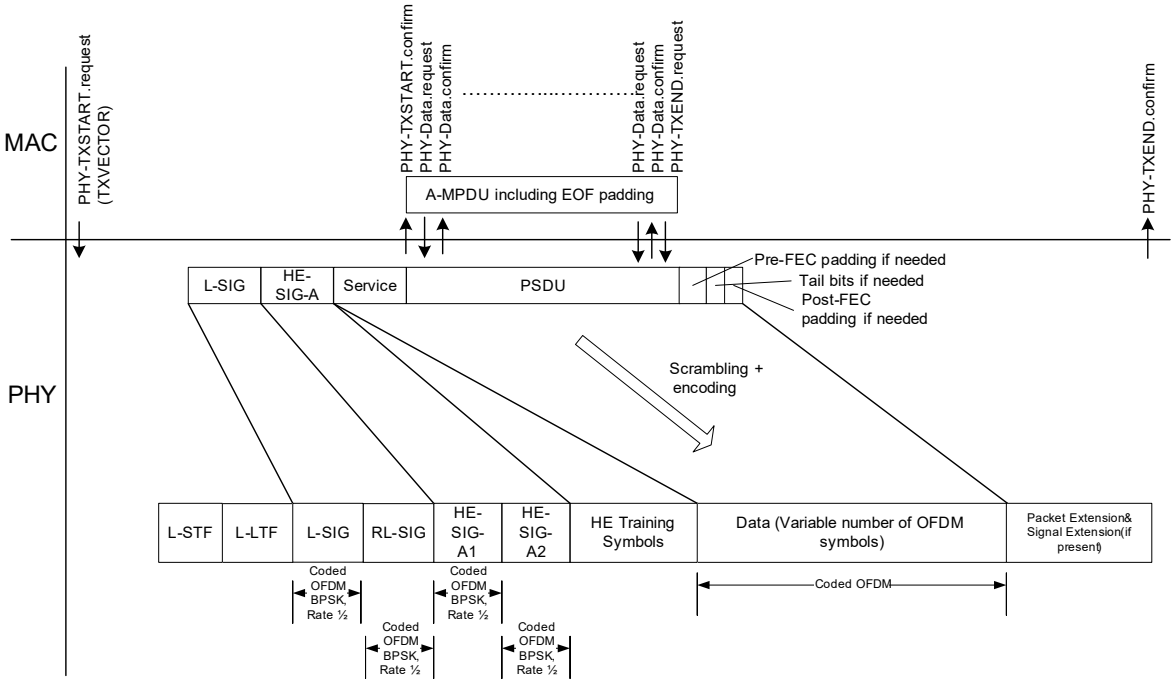
Figure 28-51—PHY transmit procedure for an HE ER SU PPDU



NOTE—This procedure does not describe the operation of optional features , such as DCM.

Figure 28-52—PHY transmit procedure for an HE MU PPDU

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NOTE—This procedure does not describe the operation of optional features , such as DCM.

Figure 28-53—PHY transmit procedure for an HE TB PPDU

The fifth option is to follow the transmit procedure in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) if the FORMAT parameter of the PHYTXSTART.request(TXVECTOR) primitive is NON_HT and the NON_HT_MODULATION parameter is set to NON_HT_DUP_OFDM except that the signal referred to in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) is instead generated simultaneously on each of the 20 MHz channels that are indicated by the CH_BANDWIDTH parameter as defined in 28.3.10 (HE preamble) and 28.3.13 (Non-HT duplicate transmission).

NOTE 1—For an HE MU PPDU the A-MPDU is per user in the MAC sublayer and the HE Training Symbols, and Data are per user in the PHY in Figure 28-52 (PHY transmit procedure for an HE MU PPDU), with the number HE Training Symbols depending on the maximum total number of space-time streams across all RUs.

NOTE 2—The transmit procedure for NON_HT, HT_MF, HT_GF, and VHT format are specified in 28.2.6 (Support for NON-HT, HT and VHT formats).

In all options, in order to transmit data, the MAC generates a PHY-TXSTART.request primitive, which causes the PHY entity to enter the transmit state. Further, the PHY is set to operate at the appropriate frequency through station management via the PLME, as specified in 28.4 (HE PLME). Other transmit parameters, such as HE-MCS Coding types and transmit power, are set via the PHY-SAP using the PHYTXSTART.request(TXVECTOR) primitive, as described in 28.2.2 (TXVECTOR and RXVECTOR parameters). The remainder of the clause applies to the first four options.

The PHY indicates the state of the primary channel and other channels (if any) via the PHY-CCA.indication primitive (see 21.3.18.5 (CCA sensitivity) and 8.3.5.12 (PHY-CCA.indication)). Transmission of the PPDU shall be initiated by the PHY after receiving the PHY-TXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request primitive are specified in Table 28-1 (TXVECTOR and RXVECTOR parameters).

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Transmission of the PHY preamble may start if TIME_OF_DEPARTURE_REQUESTED is false, and shall start immediately if TIME_OF_DEPARTURE_REQUESTED is true, based on the parameters passed in the PHY-TXSTART.request primitive.

If all of the following conditions are met:

— if dot11TODImplemented and dot11TODActivated are true or if dot11TimingMsmtActivated is true,

— the TXVECTOR parameter TIME_OF_DEPARTURE_REQUESTED is true,

then the PHY shall issue a PHY-TXSTART.confirm(TXSTATUS) primitive to the MAC, forwarding the TIME_OF_DEPARTURE corresponding to the time when the first frame energy is sent by the transmitting port and TIME_OF_DEPARTURE_ClockRate parameter within the TXSTATUS vector. If dot11TimingMsmtActivated is true, then the PHY shall forward the value of TX_START_OF_FRAME_OFFSET in TXSTATUS vector.

After the PHY preamble transmission is started, the PHY entity immediately initiates data scrambling and data encoding. The encoding method for the Data field is based on the FEC_CODING, CH_BANDWIDTH, NUM_STS, STBC, MCS, and NUM_USERS parameter of the TXVECTOR, as described in 28.3.4 (HE PPDU formats).

The SERVICE field and PSDU are encoded as described in 28.3.5 (Transmitter block diagram). The data shall be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. PHY padding bits are appended to the PSDU to make the number of bits in the coded PSDU an integral multiple of the number of coded bits per OFDM symbol.

Transmission can be prematurely terminated by the MAC through the PHY-TXEND.request primitive. PSDU transmission is terminated by receiving a PHY-TXEND.request primitive. Each PHYTXEND.request primitive is acknowledged with a PHY-TXEND.confirm primitive from the PHY.

A packet extension and/or a signal extension may be present in the PPDU. When no packet extension and signal extension are present, the PHY-TXEND.confirm primitive is generated at the end of the actual ending time of the PPDU. When a packet extension and/or a signal extension present, the PHY-TXEND.confirm primitive is generated at the end of the packet extension or signal extension.

In the PHY, the GI with GI duration indicated in GI_TYPE parameter of the TXVECTOR is inserted in every data OFDM symbol as a countermeasure against delay spread.

When the PPDU transmission is completed the PHY entity enters the receive state.

A typical state machine implementation of the transmit PHY for an HE PPDU transmission is provided in Figure 28-54 (PHY transmit state machine for an HE PPDU). Request (.request) and confirmation(.confirm)

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primitives are issued once per state as shown. This state machine does not describe the operation of optional features, such as DCM.

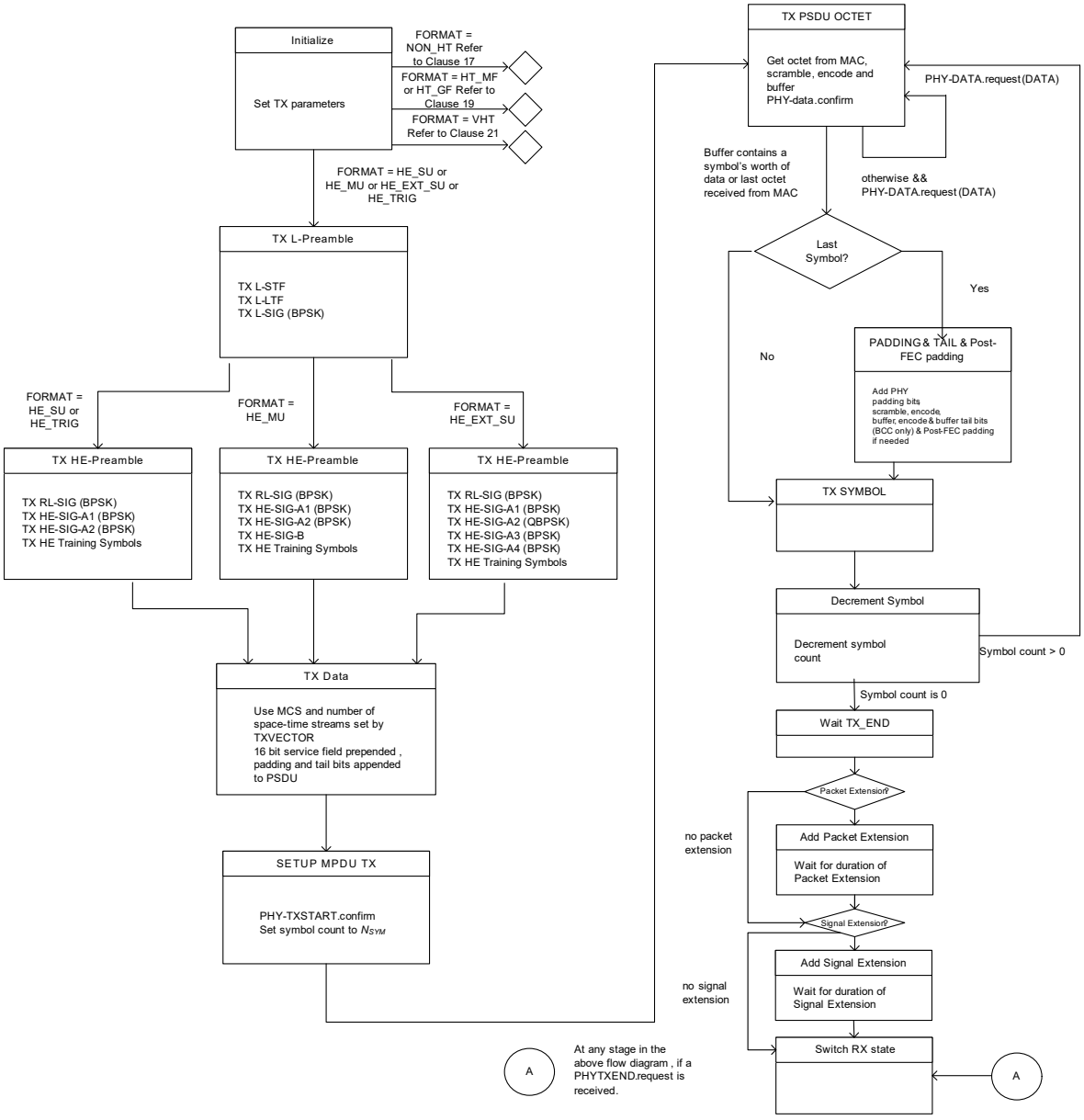


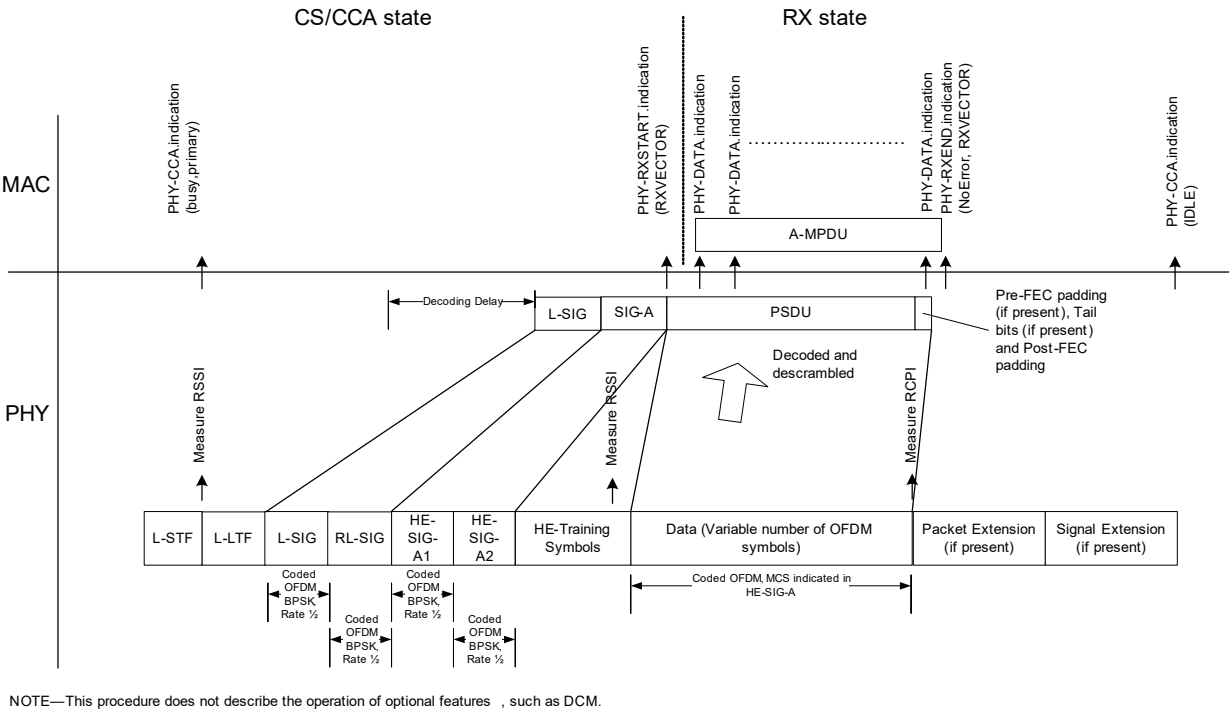
Figure 28-54—PHY transmit state machine for an HE PPDU

28.3.21 HE receive procedure

Typical PHY receive procedures are shown in Figure 28-55 (PHY receive procedure for an HE SU PPDU), Figure 28-56 (PHY receive procedure for an HE ER SU PPDU), Figure 28-57 (PHY receive procedure for an HE MU PPDU), and Figure 28-58 (PHY receive procedure for an HE TB PPDU) respectively. A typical state machine implementation of the receive PHY is given in Figure 28-59 (PHY receive state machine). This receive procedure and state machine do not describe the operation of optional features, such as DCM. If the detected format indicates a non-HT PPDU, refer to the receive procedure and state machine in Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification). If the detected format indicates

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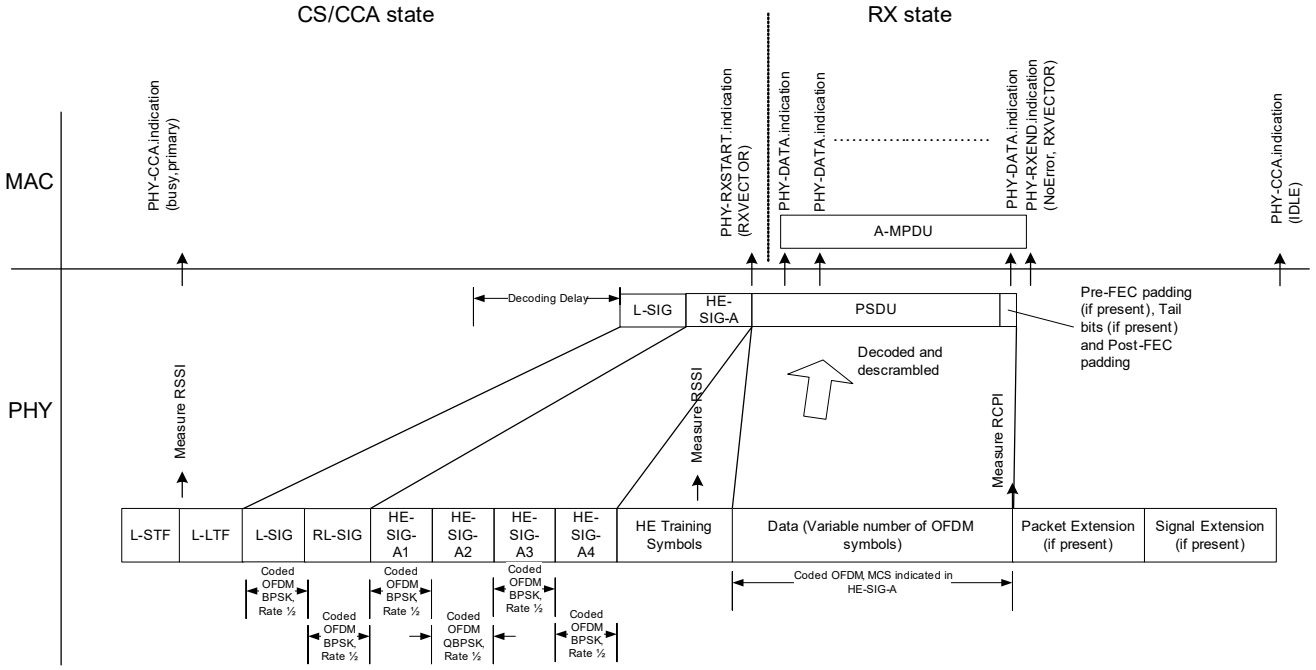
an HT PPDU format, refer to the receive procedure and state machine in Clause 19 (High Throughput (HT) PHY specification). If the detected format indicates a VHT PPDU format, refer to the receive procedure and state machine in Clause 21 (Very High Throughput (VHT) PHY specification).Through station management (via the PLME) the PHY is set to the appropriate frequency, as specified in 28.4 (HE PLME). The PHY has also been configured with BSS identification information and STA identification information (i.e., BSS Color value and STA ID in the cell) so that it can receive data intended for the STA in the specific cell. Other receive parameters, such as RSSI and indicated DATARATE, may be accessed via the PHY-SAP.



NOTE—This procedure does not describe the operation of optional features , such as DCM.

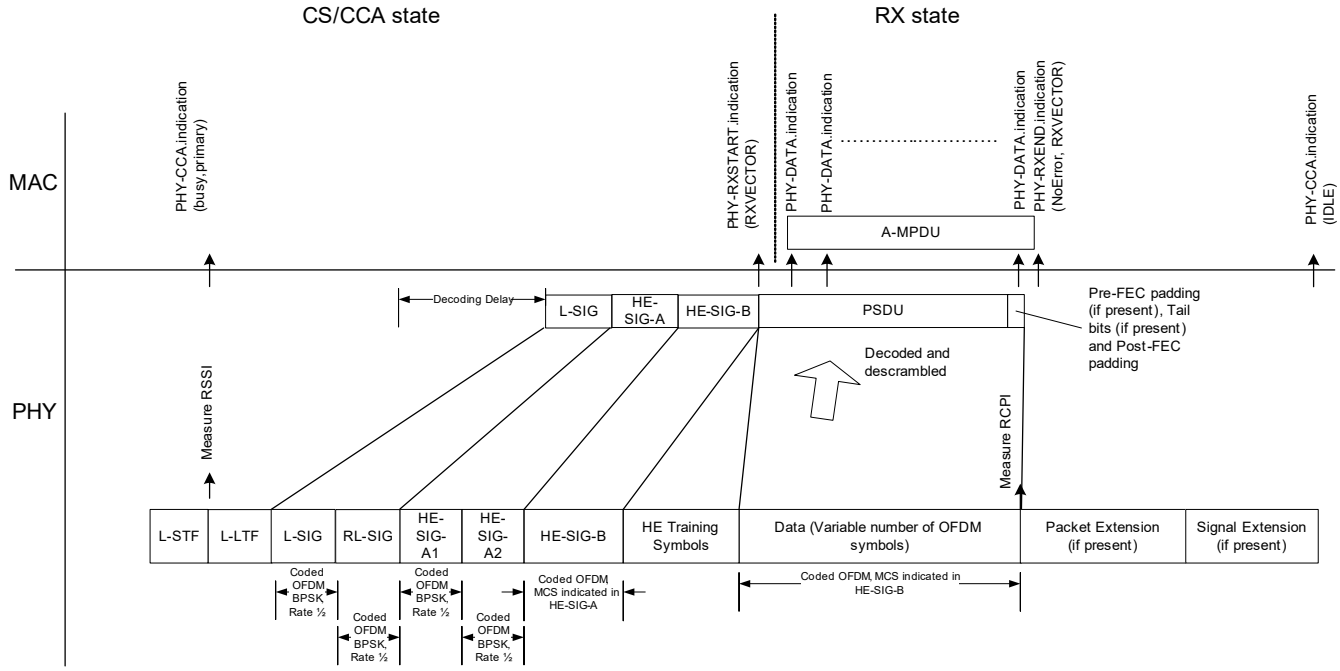
Figure 28-55—PHY receive procedure for an HE SU PPDU

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NOTE—This procedure does not describe the operation of optional features , such as DCM.

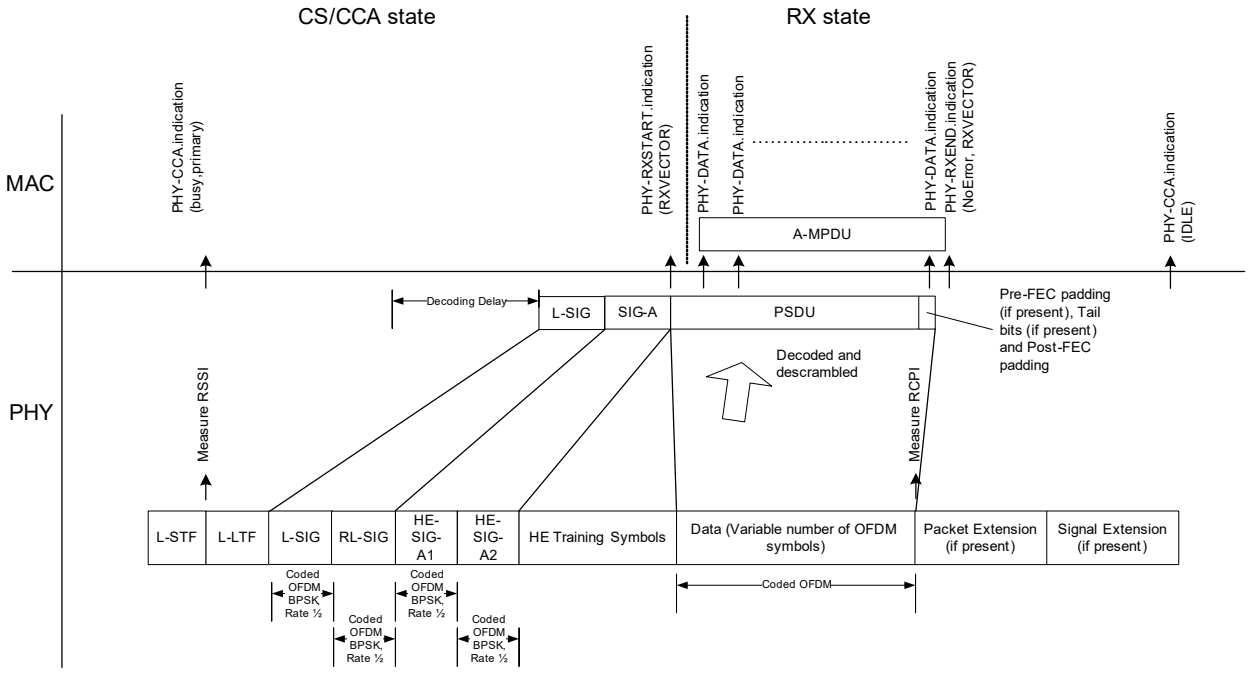
Figure 28-56—PHY receive procedure for an HE ER SU PPDU



NOTE—This procedure does not describe the operation of optional features , such as DCM.

Figure 28-57—PHY receive procedure for an HE MU PPDU

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NOTE—This procedure does not describe the operation of optional features , such as DCM.

Figure 28-58—PHY receive procedure for an HE TB PPDU

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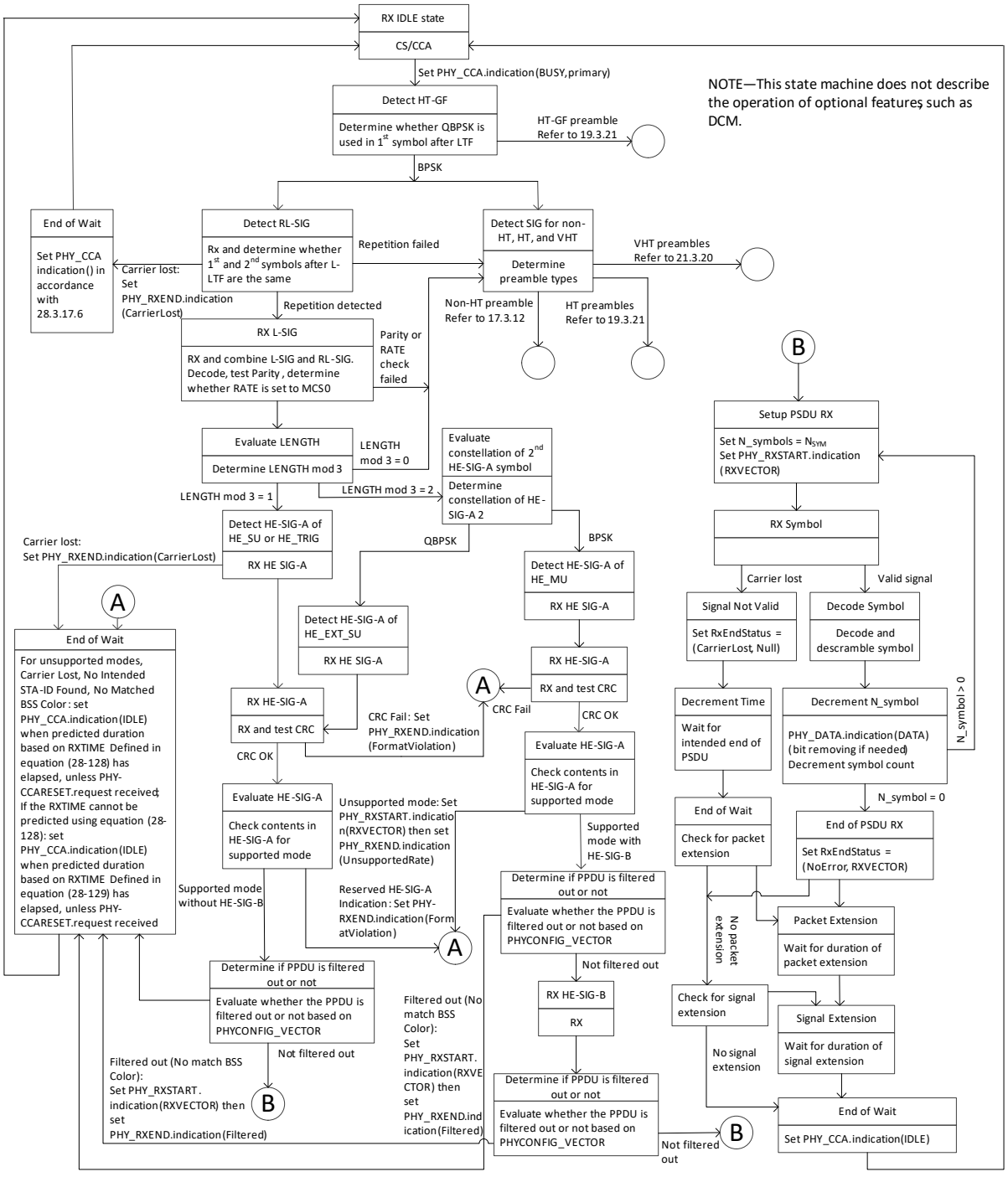


Figure 28-59—PHY receive state machine

Upon receiving the transmitted PHY preamble in a greater than or equal to 20 MHz BSS, the PHY measures a receive signal strength. This activity is indicated by the PHY to the MAC via a PHY-CCA.indication primitive. A PHY-CCA.indication(BUSY, channel-list) primitive is also issued as an initial indication of reception of a signal as specified in 21.3.18.5 (CCA sensitivity). The channel-list parameter of the PHYCCA.indication primitive is absent when the operating channel width is 20 MHz. The channel-list parameter is present when the operating channel width is 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz.

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The PHY shall not issue a PHY-RXSTART.indication primitive in response to a PPDU that does not overlap the primary channel, except when the PHY at an AP receives the HE TB PPDU solicited by the AP. For the HE TB PPDU solicited by the AP, the PHY shall issue a PHY-RXSTART.indication primitive for a PPDU received in the primary or at the secondary 20 MHz channel, the secondary 40 MHz channel, or the secondary 80 MHz channel.

The PHY includes the measured RSSI and RSSI_LEGACY value in the PHY-RXSTART.indication(RXVECTOR) primitive issued to the MAC.

After the PHY-CCA.indication(BUSY, channel-list) primitive is issued, the PHY entity shall begin receiving the training symbols and searching for the preambles for non-HT, HT, VHT, and HE PPDUs, respectively. If the constellation used in the first symbol after the first long training field is QBPSK, the PHY entity shall continue to detect the received signal using the receive procedure for HT-GF depicted in Clause 19. Otherwise, for detecting the HE preamble, the PHY entity shall search for L-SIG and RL-SIG in order to set the maximum duration of the data stream. If RL-SIG is detected, the PHY entity should check the parity bit and RATE fields in L-SIG and RL-SIG. If either the check of the parity bit is invalid or the RATE field is not set to MCS0 in non-HT, a PHY-RXSTART.indication primitive is not issued. If the check of the parity bit is valid and the RATE field is set to MCS0 but the LENGTH field value in L-SIG is a multiple of 3, a PHY-RXSTART.indication primitive is not issued. In both cases, the PHY should continue to detect the received signal using non-HT, HT, and VHT receive procedure in Clauses 17, 19, and 21, respectively.

If a valid parity bit and the RATE with MCS0 are indicated in L-SIG and RL-SIG and the LENGTH field value in L-SIG and RL-SIG meets the condition that the remainder is 1 after LENGTH divided by 3, the PHY entity should begin receiving the sequence of HE-SIG-A, HE-STF, and HE-LTF for HE SU PPDU and HE TB PPDU as shown in Figure 28-55 (PHY receive procedure for an HE SU PPDU) and Figure 28-58 (PHY receive procedure for an HE TB PPDU), respectively. After RL-SIG, the PHY entity shall receive two symbols of HE-SIG-A immediately followed by HE-STF. The PHY entity shall check CRC of HE-SIG-A. If the CRC check is valid, the PHY entity shall report TXOP, BSS Color and check Format field, and continue to receive HE-STF. The PHY entity shall report to the MAC entity the predicted duration of the TXOP in HE-SIG-A. The PHY entity shall check the BSS color in HE-SIG-A. If the BSS color does not contain an intended value, the PHY entity shall set PHY_RXSTART.indication(RXVECTOR) then set PHY_RXEND.indication(Filtered). The PHY entity shall check Format field in HE-SIG-A. If the Format field indicates an HE SU PPDU, the PHY entity shall receive HE-STF for 4 μs after HE-SIG-A. If the Format field indicates an HE TB PPDU, the PHY entity shall receive HE-STF for 8 μs after HE-SIG-A. If the HE-SIG-A indicates a valid CRC and Reserved HE-SIG-A Indication is not indicated, for all supported modes, unsupported modes, the PHY entity shall maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU, as defined by RXTIME in Equation (28-125), unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 27.9 (Spatial reuse operation). If the HE-SIG-A indicates an unsupported mode, the PHY shall issue a PHY-RXEND.indication(UnsupportedRate)primitive. If the HE-SIG-A indicates an invalid CRC or Reserved HE-SIG-A Indication, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation) primitive and maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU derived from the LENGTH field in L-SIG as defined in Equation (28-126), unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 27.9 (Spatial reuse operation). Reserved HE-SIG-A Indication is defined as an HE-SIG-A with Reserved bits equal to 0 or any other VHT-SIG-A field bit combinations that do not correspond to modes of PHY operation defined in Clause 28 (High Efficiency (HE) PHY specification). A STA, who wants to predict the duration of the HE TB PPDU, shall maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU derived from the LENGTH field in L-SIG as defined in Equation (28-126), unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 27.9 (Spatial reuse operation).

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If a valid parity bit of L-SIG and RL-SIG is indicated and the LENGTH field value in L-SIG and RL-SIG meet the condition that the remainder is 2 after LENGTH divided by 3, the PHY entity should detect the signal constellations in the second symbol after RL-SIG. If the constellation is QBPSK, the PHY entity shall continue receiving the sequence of HE-SIG-A, HE-STF, and HE-LTF for an HE ER SU PPDU shown in Figure 28-56 (PHY receive procedure for an HE ER SU PPDU). After RL-SIG, the PHY entity shall receive four symbols of HE-SIG-A immediately followed by HE-STF. The PHY entity shall check CRC of HE-SIG-A. If the CRC check is valid, the PHY entity shall report TXOP, BSS Color, and continue to receive HE-STF. The PHY entity shall report to the MAC entity the predicted duration of the TXOP in HE-SIG-A. The PHY entity shall check the BSS color in HE-SIG-A. If the BSS color does not contain an intended value, the PHY entity shall set PHY_RXSTART.indication(RXVECTOR) then set PHY_RXEND.indication(Filtered). The PHY entity shall receive HE-STF for 4 μs after HE-SIG-A. If the HE-SIG-A indicates a valid CRC and Reserved HE-SIG-A Indication is not indicated, for all supported modes, unsupported modes, the PHY entity shall maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU, as defined by RXTIME in Equation (28-125), unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 27.9 (Spatial reuse operation). If the HE-SIG-A indicates an unsupported mode, the PHY shall issue a PHY-RXEND.indication(UnsupportedRate) primitive. If the HE-SIG-A indicates an invalid CRC or Reserved HE-SIG-A Indication, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation) primitive and maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU derived from the LENGTH field in L-SIG as defined in Equation (28-126), unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 27.9 (Spatial reuse operation). Reserved HE-SIG-A Indication is defined as an HE-SIG-A with Reserved bits equal to 0 or any other VHT-SIG-A field bit combinations that do not correspond to modes of PHY operation defined in Clause 28 (High Efficiency (HE) PHY specification).

If a valid parity bit of L-SIG and RL-SIG is indicated and the LENGTH field value in L-SIG and RL-SIG meet the condition that the remainder is 2 after LENGTH divided by 3, the PHY entity should detect the signal constellations in the second symbol after RL-SIG. If the constellation is BPSK, the PHY entity shall continue receiving the sequence of HE-SIG-A, HE-SIG-B, HE-STF, and HE-LTF for an HE MU PPDU shown in Figure 28-57 (PHY receive procedure for an HE MU PPDU). After RL-SIG, the PHY entity shall receive two symbols of HE-SIG-A immediately followed by HE-SIG-B. The PHY entity shall check CRC of HE-SIG-A. If the CRC check is valid, the PHY entity shall report TXOP, BSS Color, and continue to receive HE-SIG-B. The PHY entity shall report to the MAC entity the predicted duration of the TXOP in HE-SIG-A. The PHY entity shall check the BSS color in HE-SIG-A. If the BSS color doesn't contain an intended value, the PHY entity shall set PHY_RXSTART.indication(RXVECTOR) then set PHY_RXEND.indication(Filtered). After HE-SIG-A, the PHY entity shall receive HE-SIG-B for the number of symbols predicted from HE-SIG-A. If the Common field is present in HE-SIG-B, the PHY entity shall check the CRC of the Common field. If the CRC in the Common field is valid or the Common field is not present, the PHY entity shall search for intended STA-ID in each User Specific subfield with a valid CRC. If no CRC is valid or no intended STA-ID is detected, the PHY entity shall set PHY_RXSTART.indication(RXVECTOR) then set PHY_RXEND.indication(Filtered). If a complete allocation of an intended STA-ID is detected in block with valid CRC, the PHY entity shall continue receiving HE-STF for 4 μs after HE-SIG-B for the detected and intended STA. If the HE-SIG-A indicates a valid CRC and Reserved HE-SIG-A Indication is not indicated, for all supported modes, unsupported modes, the PHY entity shall maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU, as defined by RXTIME in Equation (28-125), unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in 27.9 (Spatial reuse operation). If the HE-SIG-A indicates an unsupported mode, the PHY shall issue a PHY-RXEND.indication(UnsupportedRate) primitive. If the HE-SIG-A indicates an invalid CRC or Reserved HE-SIG-A Indication, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation) primitive and maintain PHY-CCA.indication(BUSY, channellist) primitive for the predicted duration of the transmitted PPDU derived from the LENGTH field in L-SIG as defined in Equation (28-125), unless it receives a PHY-CCARESET.request primitive before the end of the PPDU for instance during spatial reuse operation as described in

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27.9 (Spatial reuse operation). Reserved HE-SIG-A Indication is defined as an HE-SIG-A with Reserved bits equal to 0 or any other VHT-SIG-A field bit combinations that do not correspond to modes of PHY operation defined in Clause 28 (High Efficiency (HE) PHY specification).

If signal loss occurs during reception prior to completion of the PSDU reception, the error condition PHYRXEND. indication(CarrierLost) shall be reported to the MAC. After waiting for the end of the PPDU as determined by Equation (28-125) the PHY shall set the PHY-CCA.indication (IDLE) primitive and return to the RX IDLE state.

$$\text{RXTIME}(\mu s) = 20 + T_{\text{HE\_PREAMBLE}} + N_{SYM}T_{SYM} + N_{MA}N_{\text{HE-LTF}}T_{\text{HE-LTF-SYM}} + T_{PE} + SignalExtension \quad (28\text{-}125)$$

where

$T_{\text{HE\_PREAMBLE}}$, N_{SYM}, T_{PE} and N_{MA} are defined in Equation (28-114), Equation (28-115) and Equation (28-116), respectively.

SignalExtension is 0 μs when TXVECTOR parameter NO_SIG_EXTN is true and is aSignalExtension as defined in Table 19-25 (HT PHY characteristics) when TXVECTOR parameter NO_SIG_EXTN is false.

$$\text{RXTIME}(\mu s) = \left\lceil \frac{\text{LENGTH} + 3}{3} \right\rceil \cdot 4 + 20 + SignalExtension \quad (28\text{-}126)$$

where

LENGTH is the LENGTH field in L-SIG

SignalExtension is defined in Table 19-25 (HT PHY characteristics)

Except in an HE NDP PPDU and HE TB NDP feedback PPDU, a Data field follows the HE-STF and HE-LTF fields. The number of symbols in the Data field and the packet extension duration are computed from Equation (28-114) and Equation (28-115), respectively.

The received PSDU bits are assembled into octets, decoded, and present to the MAC using a series of PHY-DATA.indication(DATA) primitive exchanges. Any final bits that cannot be assembled into a complete octet are considered pad bits and discarded. After the reception of the final bit of the last PSDU octet, and possible padding and tail bits, the PHY entity shall check whether packet extension and/or signal extension is applied. If packet extension and/or signal extension is applied, the PHY entity shall wait until the packet extension and/or signal extension expires before returning to the RX IDLE state, as shown in Figure 28-59 (PHY receive state machine).

28.4 HE PLME

28.4.1 PLME_SAP sublayer management primitives

Table 28-49 (VHT PHY MIB attributes) lists the MIB attributes that may be accessed by the PHY entities and the intralayer of higher level LMEs. These attributes are accessed via the PLME-GET, PLME-SET, PLME-RESET, and PLME-CHARACTERISTICS primitives defined in 6.5 (PLME SAP interface).

28.4.2 PHY MIB

HE PHY MIB attributes are defined in Annex C with specific values defined in Table 28-49 (VHT PHY MIB attributes). The “Operational semantics” column in Table 28-49 (VHT PHY MIB attributes) contains two types: static and dynamic.

— Static MIB attributes are fixed and cannot be modified for a given PHY implementation.

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— Dynamic MIB attributes are interpreted according to the MAX-ACCESS field of the MIB attribute. When MAX-ACCESS is equal to read-only, the MIB attribute value may be updated by the PLME and read from the MIB attribute by management entities. When MAX-ACCESS is equal to read-write, the MIB attribute may be read and written by management entities.

Table 28-49—VHT PHY MIB attributes

Managed object	Default value/ range	Operational semantics
dot11PHYOperationTable		
dot11PHYType	he<ANA>	Static
dot11PHYTxPowerTable		
dot11NumberSupportedPowerLevelsImplemented	Implementation dependent	Static
dot11TxPowerLevel1	Implementation dependent	Static
dot11TxPowerLevel2	Implementation dependent	Static
dot11TxPowerLevel3	Implementation dependent	Static
dot11TxPowerLevel4	Implementation dependent	Static
dot11TxPowerLevel5	Implementation dependent	Static
dot11TxPowerLevel6	Implementation dependent	Static
dot11TxPowerLevel7	Implementation dependent	Static
dot11TxPowerLevel8	Implementation dependent	Static
dot11CurrentTxPowerLevel	Implementation dependent	Static
dot11TxPowerLevelExtended	Implementation dependent	Static
dot11CurrentTxPowerLevelExtended	Implementation dependent	Static
dot11PHYHTTable		
dot11CurrentPrimaryChannel	Implementation dependent	Dynamic
dot11CurrentSecondaryChannel	Implementation dependent	Dynamic
dot11FortyMHzOperationImplemented	false/Boolean	Static
dot11FortyMHzOperationActivated	false/Boolean	Dynamic

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Table 28-49—VHT PHY MIB attributes *(continued)*

Managed object	Default value/ range	Operational semantics
dot11NumberOfSpatialStreamsImplemented	Implementation dependent	Static
dot11NumberOfSpatialStreamsActivated	Implementation dependent	Dynamic
dot11HTGreenfieldOptionImplemented	false/Boolean	Static
dot11HTGreenfieldOptionActivated	false/Boolean	Dynamic
dot11ShortGIOptionInTwentyImplemented	false/Boolean	Static
dot11ShortGIOptionInTwentyActivated	false/Boolean	Dynamic
dot11ShortGIOptionInFortyImplemented	false/Boolean	Static
dot11ShortGIOptionInFortyActivated	false/Boolean	Dynamic
dot11LDPCCodingOptionImplemented	false/Boolean	Static
dot11LDPCCodingOptionActivated	false/Boolean	Dynamic
dot11TxSTBCOptionImplemented	false/Boolean	Static
dot11TxSTBCOptionActivated	false/Boolean	Dynamic
dot11RxSTBCOptionImplemented	false/Boolean	Static
dot11RxSTBCOptionActivated	false/Boolean	Dynamic
dot11BeamFormingOptionImplemented	false/Boolean	Static
dot11BeamFormingOptionActivated	false/Boolean	Dynamic
dot11PHYVHTTable		
dot11CurrentChannelWidth	Implementation dependent	Dynamic
dot11CurrentChannelCenterFrequencyIndex0	Implementation dependent	Dynamic
dot11CurrentChannelCenterFrequencyIndex1	Implementation dependent	Dynamic
dot11VHTChannelWidthOptionImplemented	Implementation dependent	Static
dot11VHTShortGIOptionIn80Implemented	false/Boolean	Static
dot11VHTShortGIOptionIn80Activated	false/Boolean	Dynamic
dot11VHTShortGIOptionIn160and80p80Implemented	false/Boolean	Static
dot11VHTShortGIOptionIn160and80p80Activated	false/Boolean	Dynamic
dot11VHTLDPCCodingOptionImplemented	false/Boolean	Static
dot11VHTLDPCCodingOptionActivated	false/Boolean	Dynamic
dot11VHTTxSTBCOptionImplemented	false/Boolean	Static
dot11VHTTxSTBCOptionActivated	false/Boolean	Dynamic

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Table 28-49—VHT PHY MIB attributes *(continued)*

Managed object	Default value/ range	Operational semantics
dot11VHTRxSTBCOptionImplemented	false/Boolean	Static
dot11VHTRxSTBCOptionActivated	false/Boolean	Dynamic
dot11VHTMaxNTxChainsImplemented	Implementation dependent	Static
dot11VHTMaxNTxChainsActivated	Implementation dependent	Dynamic
dot11TransmitBeamformingConfigTable		
dot11ReceiveStaggerSoundingOptionImplemented	false/Boolean	Static
dot11TransmitStaggerSoundingOptionImplemented	false/Boolean	Static
dot11ReceiveNDPOptionImplemented	false/Boolean	Static
dot11TransmitNDPOptionImplemented	false/Boolean	Static
dot11ImplicitTransmitBeamformingOptionImplemented	false/Boolean	Static
dot11CalibrationOptionImplemented	Implementation dependent	Static
dot11ExplicitCSITransmitBeamformingOptionImplemented	false/Boolean	Static
dot11ExplicitNonCompressedBeamformingMatrixOptionImplemented	false/Boolean	Static
dot11ExplicitTransmitBeamformingCSIFeedbackOptionImplemented	Implementation dependent	Static
dot11ExplicitNoncompressedBeamformingFeedbackOptionImplemented	Implementation dependent	Static
dot11ExplicitCompressedBeamformingFeedbackOptionImplemented	Implementation dependent	Static
dot11NumberBeamFormingCSISupportAntenna	Implementation dependent	Static
dot11NumberNonCompressedBeamformingMatrixSupportAntenna	Implementation dependent	Static
dot11NumberCompressedBeamformingMatrixSupportAntenna	Implementation dependent	Static
dot11VHTTransmitBeamformingConfigTable		
dot11VHTSUBeamformeeOptionImplemented	false/Boolean	Static
dot11VHTSUBeamformerOptionImplemented	false/Boolean	Static
dot11VHTMUBeamformeeOptionImplemented	false/Boolean	Static
dot11VHTMUBeamformerOptionImplemented	false/Boolean	Static
dot11VHTNumberSoundingDimensions	Implementation dependent	Static
dot11VHTBeamformeeNTxSupport	Implementation dependent	Static

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Table 28-49—VHT PHY MIB attributes *(continued)*

Managed object	Default value/ range	Operational semantics
dot11PHYHETable		
dot11HEDualBandImplemented	false/Boolean	Static
dot11HECurrentChannelWidthSet	Implementation dependent	Dynamic
dot11HEPuncturedPreambleTxImplemented	Implementation dependent	Static
dot11HEPuncturedPreambleTxActivated	Implementation dependent	Dynamic
dot11HEPuncturedPreambleRxImplemented	Implementation dependent	Static
dot11HEPuncturedPreambleRxActivated	Implementation dependent	Dynamic
dot11HEDeviceClass	Implementation dependent	Static
dot11HELPDCCodingInPayloadImplemented	false/Boolean	Static
dot11HELPDCCodingInPayloadActivated	false/Boolean	Dynamic
dot11HESUPPDUwith1xHELTFand0point8GIImplemented	false/Boolean	Static
dot11HESUPPDUwith1xHELTFand0point8GIActivated	false/Boolean	Dynamic
dot11HESUPPDUwith4xHELTFand0point8GIImplemented	false/Boolean	Static
dot11HESUPPDUwith4xHELTFand0point8GIActivated	false/Boolean	Dynamic
dot11HENDPwith4xHELTFand3point2GIImplemented	false/Boolean	Static
dot11HENDPwith4xHELTFand3point2GIActivated	false/Boolean	Dynamic
dot11HESTBCTxLessThanOrEqualTo80Implemented	false/Boolean	Static
dot11HESTBCTxLessThanOrEqualTo80Activated	false/Boolean	Dynamic
dot11HESTBCRxLessThanOrEqualTo80Implemented	false/Boolean	Static
dot11HESTBCRxLessThanOrEqualTo80Activated	false/Boolean	Dynamic
dot11HESTBCTxGreaterThan80Implemented	false/Boolean	Static
dot11HESTBCTxGreaterThan80Activated	false/Boolean	Dynamic
dot11HESTBCRxGreaterThan80Implemented	false/Boolean	Static
dot11HESTBCRxGreaterThan80Activated	false/Boolean	Dynamic
dot11HEDopplerImplemented	false/Boolean	Static
dot11HEDopplerActivated	false/Boolean	Dynamic
dot11HEDCMImplemented	Implementation dependent	Static
dot11HEDCMActivated	Implementation dependent	Dynamic

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Table 28-49—VHT PHY MIB attributes *(continued)*

Managed object	Default value/ range	Operational semantics
dot11HEFullBWULMUMIMOImplemented	false/Boolean	Static
dot11HEFullBWULMUMIMOActivated	false/Boolean	Dynamic
dot11HEPartialBWULMUMIMOImplemented	false/Boolean	Static
dot11HEPartialBWULMUMIMOActivated	false/Boolean	Dynamic
dot11HEPartialBWDLMUMIMOImplemented	false/Boolean	Static
dot11HEPartialBWDLMUMIMOActivated	false/Boolean	Dynamic
dot11HEULMUPayloadImplemented	false/Boolean	Static
dot11HEULMUPayloadActivated	false/Boolean	Dynamic
dot11HEPowerBoostFactorImplemented	false/Boolean	Static
dot11HEPowerBoostFactorActivated	false/Boolean	Dynamic
dot11HEPartialBWERSUPayloadImplemented	false/Boolean	Static
dot11HEPartialBWERSUPayloadActivated	false/Boolean	Dynamic
dot11HETransmitBeamformingConfigTable		
dot11HESUBeamformerOptionImplemented	false/Boolean	Static
dot11HESUBeamformeeOptionImplemented	false/Boolean	Static
dot11HEMUBeamformerOptionImplemented	false/Boolean	Static
dot11HEBeamformeeSTSSupportLessThanOrEqualTo80	Implementation dependent	Static
dot11HEBeamformeeSTSSupportGreaterThan80	Implementation dependent	Static
dot11HENumberSoundingDimensionsLessThanOrEqualTo80	Implementation dependent	Static
dot11HENumberSoundingDimensionsGreaterThan80	Implementation dependent	Static
dot11HENG16SUFeedbackSupport	false/Boolean	Static
dot11HENG16MUFeedbackSupport	false/Boolean	Static
dot11HECodebookSizePhi4Psi2SUFeedbackSupport	false/Boolean	Static
dot11HECodebookSizePhi7Psi5MUFeedbackSupport	false/Boolean	Static
dot11HETriggeredSUBeamformingFeedbackImplemented	false/Boolean	Static
dot11HETriggeredSUBeamformingFeedbackActivated	false/Boolean	Dynamic
dot11HETriggeredMUBeamformingFeedbackImplemented	false/Boolean	Static
dot11HETriggeredMUBeamformingFeedbackActivated	false/Boolean	Dynamic
dot11HETriggeredCQIFeedbackSupportImplemented	false/Boolean	Static
dot11HETriggeredCQIFeedbackSupportActivated	false/Boolean	Dynamic

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28.4.3 TXTIME and PSDU_LENGTH calculation

The value of the TXTIME parameter returned by the PLME-TXTIME.confirm primitive shall be calculated for an HE PPDU using Equation (28-127).

$$\text{TXTIME} = 20 + T_{\text{HE\_PREAMBLE}} + N_{SYM}T_{SYM} + N_{MA}N_{\text{HE-LTF}}T_{\text{HE-LTF-SYM}} + T_{PE} + SignalExtension \quad (28\text{-}127)$$

where

$T_{\text{HE\_PREAMBLE}}$ is defined as in Equation (28-114) and Equation (28-115), and *SignalExtension* takes the value of aSignalExtension as defined in Table 19-25 (HT PHY characteristics).

For an HE NDP PPDU and HE TB NDP feedback PPDU, there is no Data field and $N_{SYM} = 0$.

For an HE SU PPDU and HE ER SU PPDU using BCC encoding, the total number of OFDM symbols in the Data field is given by Equation (28-61).

For an HE SU PPDU and HE ER SU PPDU using LDPC encoding, the total number of OFDM symbols in the Data field, N_{SYM}, is given in 28.3.11.5.2 (LDPC coding).

For an HE MU PPDU (including both MU-MIMO and OFDMA), the total number of OFDM symbols in the Data field, N_{SYM}, is given in 28.3.11.5.4 (Encoding process for an HE MU PPDU).

For an HE TB PPDU, the total number of OFDM symbols in the Data field, N_{SYM}, is given in 28.3.11.5.5 (Encoding process for an HE TB PPDU).

T_{PE} is given in 28.3.12 (Packet extension).

N_{MA} is the number of midambles. It is given by Equation (28-112) if the TXVECTOR value DOPPLER is 1, and is 0 otherwise.

$N_{HE\text{-}LTF}$ and $T_{HE\text{-}LTF}$ are given in 28.3.8 (Timing-related parameters).

The value of the PSDU_LENGTH parameter returned in the PLME-TXTIME.confirm primitive for an HE SU PPDU and HE ER SU PPDU is calculated using Equation (28-128).

$$\text{PSDU\_LENGTH} = \left\lfloor \frac{(N_{SYM,init} - m_{STBC})N_{DBPS} + m_{STBC}N_{DBPS,last,init} - N_{service} - N_{tail}}{8} \right\rfloor \quad (28\text{-}128)$$

where

$N_{SYM,init}$ is given by Equation (28-60) for BCC encoding and by Equation (28-65) for LDPC encoding

m_{STBC} is 2 when STBC is used, and 1 otherwise

N_{DBPS} is given in 28.5 (Parameters for HE-MCSs)

$N_{DBPS,last,init}$ is given by Equation (28-57)

The value of the PSDU_LENGTH parameter for user u returned in the PLME-TXTIME.confirm primitive for an HE MU PPDU is calculated using Equation (28-129) and Equation (28-130) for users using BCC and LDPC, respectively.

$$\text{PSDU\_LENGTH}_u = \left\lfloor \frac{(N_{SYM} - m_{STBC})N_{DBPS,u} + m_{STBC}N_{DBPS,last,u} - N_{service} - N_{tail}}{8} \right\rfloor \quad (28\text{-}129)$$

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$$\text{PSDU\_LENGTH}_u = \left\lfloor \frac{(N_{SYM,init} - m_{STBC})N_{DBPS,u} + m_{STBC}N_{DBPS,last,init,u} - N_{service}}{8} \right\rfloor \quad (28\text{-}130)$$

where

$N_{SYM,init}$ is given by Equation (28-73)

$N_{DBPS,last,u}$ is given by Equation (28-82)

$N_{DBPS,last,init,u}$is given by Equation (28-74)

For an HE SU PPDU and HE ER SU PPDU, the value of the PSDU_LENGTH parameter returned in the RXVECTOR is calculated using Equation (28-131).

$$\text{PSDU\_LENGTH} = \left\lfloor \frac{(N_{SYM,RX} - m_{STBC})N_{DBPS} + m_{STBC}N_{DBPS,last,RX} - N_{service} - N_{tail}}{8} \right\rfloor \quad (28\text{-}131)$$

where

$N_{SYM,RX}$ is given by Equation (28-132)

m_{STBC} is 1 if the STBC field in HE-SIG-A is 0 and 2 if the STBC field is 1

$N_{DBPS,last,RX}$ is given by Equation (28-133)

N_{DBPS} is defined in Table 28-15 (Frequently used parameters)

$N_{service}$ and N_{tail} are defined in Table 28-12 (Timing-related constants)

$$N_{SYM,RX} = \begin{cases} N_{SYM} - m_{STBC}, & \text{if the Coding field is 1, the LDPC Extra Symbol Segment field is 1, and the Pre-FEC Padding Factor field is 1 in HE-SIG-A} \\ N_{SYM}, & \text{othewise} \end{cases} \quad (28\text{-}132)$$

where

N_{SYM} is given by Equation (28-114)

$$N_{DBPS,last,RX} = \begin{cases} N_{DBPS}, & \text{if } a_{RX} = 4 \\ a_{RX} \cdot N_{SD,short} \cdot N_{SS} \cdot N_{BPSCS} \cdot R, & \text{if } a_{RX} > 0 \end{cases} \quad (28\text{-}133)$$

where

a_{RX} is given by Equation (28-134)

$N_{SD,short}$ is defined in Table 28-29 (NSD,short values)

N_{SS}, N_{BPSCS}, R are defined in Table 28-15 (Frequently used parameters)

$$a_{RX} = \begin{cases} 4, & \text{if } a = 1, \text{ the Coding field is 1 and the LDPC Extra Symbol Segment field is 1 in HE-SIG-A} \\ a - 1, & \text{if } a > 1, \text{ the Coding field is 1 and the LDPC Extra Symbol Segment field is 1 in HE-SIG-A} \\ a, & \text{otherwise} \end{cases} \quad (28\text{-}134)$$

where

a is the pre-FEC padding factor (ranging from 1 to 4) indicated in HE-SIG-A

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For an HE MU PPDU, the value of the RXVECTOR parameter PSDU_LENGTH returned for user u is calculated using Equation (28-135).

$$\text{PSDU\_LENGTH}_u = \left\lfloor \frac{(N_{SYM,RX,u} - m_{STBC})N_{DBPS,u} + m_{STBC}N_{DBPS,last,RX,u} - N_{service} - N_{tail,u}}{8} \right\rfloor \quad (28\text{-}135)$$

where

$N_{SYM,RX,u}$ is given by Equation (28-136)

m_{STBC} is 1 if the STBC field in HE-SIG-A is 0 and 2 if the STBC field is 1

$N_{DBPS,last,RX,u}$ is given by Equation (28-137)

$N_{DBPS,u}$ is defined in Table 28-15 (Frequently used parameters)

$N_{service}$ and N_{tail} are defined in Table 28-12 (Timing-related constants)

$$N_{SYM,RX,u} = \begin{cases} N_{SYM} - m_{STBC}, & \text{if } a = 1, \text{ the Coding field is 1 in the HE-SIG-B User field corresponding to user u and the LDPC Extra Symbol Segment field is 1 in HE-SIG-A} \\ N_{SYM}, & \text{othewise} \end{cases} \quad (28\text{-}136)$$

where

N_{SYM} is given by Equation (28-114)

$$N_{DBPS,last,RX,u} = \begin{cases} N_{DBPS,u}, & \text{if } a_{RX} = 4 \\ a_{RX,u} \cdot N_{SD,SHORT,u} \cdot N_{SS,u} \cdot N_{BPSCS,u} \cdot R_u, & \text{otherwise} \end{cases} \quad (28\text{-}137)$$

where

$a_{RX,u}$ is given by Equation (28-138)

$N_{SD,short,u}$ is $N_{SD,short}$ defined in Table 28-29 (NSD,short values) for user u

$N_{SS,u}$, $N_{BPSCS,u}$, R_u are defined in Table 28-15 (Frequently used parameters)

$$a_{RX,u} = \begin{cases} 4, & \text{if } a = 1, \text{ the Coding field is 1 in the HE-SIG-B User field corresponding to the user } u \text{ and the LDPCExtra Symbol Segment field is 1 in HE-SIG-A} \\ a - 1, & \text{if } a > 1, \text{ the Coding field is 1 in the HE-SIG-B User field corresponding to the user } u \text{ and the LDPCExtra Symbol Segment field is 1 in HE-SIG-A} \\ a, & \text{otherwise} \end{cases} \quad (28\text{-}138)$$

where

a is the pre-FEC padding factor (ranging from 1 to 4) indicated in HE-SIG-A

The value of the PSDU_LENGTH parameter returned in the PLME-TXTIME.confirm primitive for an HE NDP PPDU is 0.

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28.4.4 HE PHY

The static HE PHY characteristics, provided through the PLME-CHARACTERISTICS service primitive, shall be as shown in Table 20-25 (HT PHY characteristics) unless otherwise listed in Table 28-50 (HE PHY characteristics). The definitions for these characteristics are given in 6.5 (PLME SAP interface).

Table 28-50—HE PHY characteristics

Characteristic	Value
aTxPHYDelay	Implementation dependent
aRxPHYDelay	Implementation dependent
aCCAMidTime	25 μs
aPPDUMaxTime	5.484 ms
aPSDUMaxLength	6 500 631 octets (see NOTE)
aRxPHYStartDelay	40 μs

NOTE—This is the maximum length in octets for an HE SU PPDU with a bandwidth of 160 MHz or 80+80 MHz using 2×996 RU, HE-MCS 11, 8 spatial streams, 0.8 μs GI duration, 1x LTF, LDPC coding, 0 μs duration of the Packet Extension, pre-FEC padding factor value of 4, and limited by 398 possible data symbols in aPPDUMaxTime. This is the maximum PSDU length an HE PHY could support assuming no restrictions in MAC. See 10.3.2 (Procedures common to the DCF and EDCAF) and 9.2.4.7.1 (General) for additional restrictions on the maximum number of octets the MAC could support.

28.5 Parameters for HE-MCSs

The rate-dependent parameters for 26-tone RU, 52-tone RU, 106-tone RU, 242-tone RU and non-OFDMA 20 MHz, 484-tone RU and non-OFDMA 40 MHz, 996-tone RU and non-OFDMA 80 MHz, 2×996-tone RU and non-OFDMA 160 MHz and 80+80 MHz N_{SS} = 1, …, 8 are given in Table 28-51 (HE-MCSs for 26-tone RU, NSS = 1) through Table 28-106 (HE-MCSs for non-OFDMA 160 MHz and 80+80 MHz, NSS = 8). Support for HE-MCS 8, 9, 10, and 11 (when valid) is optional in all cases. HE-MCS 10 and 11 (1024-QAM) are applicable only to RU sizes equal to or larger than 242 tones.

Dual carrier modulation (DCM) is an optional modulation scheme for any OFDMA and non OFDMA transmissions. DCM is only applied to MCS 0, MCS 1, MCS 3 and MCS 4. DCM is applied only with N_{SS} = 1 or N_{SS} = 2 (in the case of single user RU in an HE MU PPDU, $N_{SS,r,u}$ = 1 or $N_{SS,r,u}$ = 2). An HE STA shall support single spatial stream HE-MCSs within the range HE-MCS 0 to HE-MCS 7 for all channel widths for which it has indicated support regardless of the setting of the Supported HE-MCS And NSS Set field. When more than one spatial stream is supported, the Max HE-MCS For *n* SS subfield values in the Rx HE-MCS Map and Tx HE-MCS Map subfields of the Supported HE-MCS And NSS Set field may result in a reduced HE-MCS range (cut-off) for N_{SS} = 2, …, 8. Support for OFDMA 26-tone RU, 52-tone RU, 106-tone RU, 242-tone RU and 996-tone RU with N_{SS} = 1 is mandatory. Support for non-OFDMA 20 MHz, 40 MHz, and 80 MHz with N_{SS} = 1 is mandatory. Support for more than one spatial stream is optional in all cases. Support for OFDMA and non-OFDMA 160 MHz and 80+80 MHz with N_{SS} = 1, …, 8 is optional.

Table 28-51 (HE-MCSs for 26-tone RU, NSS = 1) to Table 28-106 (HE-MCSs for non-OFDMA 160 MHz and 80+80 MHz, NSS = 8) define HE-MCSs not only for SU transmission but also for user *u* at *r*-th RU of

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an MU transmission. In the case of HE-MCSs for MU transmissions, the parameters, N_{SS}, R, N_{BPSCS}, N_{CBPS}, and N_{DBPS} are replaced with $N_{SS,u}$, R_u, $N_{BPSCS,u}$, $N_{CBPS,u}$, and $N_{DBPS,u}$, respectively.

Table 28-51—HE-MCSs for 26-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	12	12	6	0.4	0.4	0.4
	0		1/2		24	24	12	0.9	0.8	0.8
1	1	QPSK	1/2	2	12	24	12	0.9	0.8	0.8
	0		1/2		24	48	24	1.8	1.7	1.5
2	N/A		3/4		24	48	36	2.6	2.5	2.3
3	1	16-QAM	1/2	4	12	48	24	1.8	1.7	1.5
	0		1/2		24	96	48	3.5	3.3	3.0
4	1		3/4		12	48	36	2.6	2.5	2.3
	0		3/4		24	96	72	5.3	5.0	4.5
5	N/A	64-QAM	2/3	6	24	144	96	7.1	6.7	6.0
6			3/4				108	7.9	7.5	6.8
7			5/6				120	8.8	8.3	7.5
8		256-QAM	3/4	8		192	144	10.6	10.0	9.0
9			5/6				160	11.8	11.1	10.0

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Table 28-52—HE-MCSs for 26-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	12	24	12	0.9	0.8	0.8
	0		1/2		24	48	24	1.8	1.7	1.5
1	1	QPSK	1/2	2	12	48	24	1.8	1.7	1.5
	0		1/2		24	96	48	3.5	3.3	3.0
2	N/A		3/4		24	96	72	5.3	5.0	4.5
3	1	16-QAM	1/2	4	12	96	48	3.5	3.3	3.0
	0		1/2		24	192	96	7.1	6.7	6.0
4	1		3/4		12	96	72	5.3	5.0	4.5
	0		3/4		24	192	144	10.6	10.0	9.0
5	N/A	64-QAM	2/3	6	24	288	192	14.1	13.3	12.0
6			3/4				216	15.9	15.0	13.5
7			5/6				240	17.6	16.7	15.0
8		256-QAM	3/4	8		384	288	21.2	20.0	18.0
9			5/6				320	23.5	22.2	20.0

Table 28-53—HE-MCSs for 26-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	24	72	36	2.6	2.5	2.3
1		QPSK	1/2	2		144	72	5.3	5.0	4.5
2			3/4				108	7.9	7.5	6.8
3		16-QAM	1/2	4		288	144	10.6	10.0	9.0
4			3/4				216	15.9	15.0	13.5
5		64-QAM	2/3	6		432	288	21.2	20.0	18.0
6			3/4				324	23.8	22.5	20.3
7			5/6				360	26.5	25.0	22.5
8		256-QAM	3/4	8		576	432	31.8	30.0	27.0
9			5/6				480	35.3	33.3	30.0

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Table 28-54—HE-MCSs for 26-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	24	96	48	3.5	3.3	3.0
1		QPSK	1/2	2		192	96	7.1	6.7	6.0
2			3/4				144	10.6	10.0	9.0
3		16-QAM	1/2	4		384	192	14.1	13.3	12.0
4			3/4				288	21.2	20.0	18.0
5		64-QAM	2/3	6		576	384	28.2	26.7	24.0
6			3/4				432	31.8	30.0	27.0
7			5/6				480	35.3	33.3	30.0
8		256-QAM	3/4	8		768	576	42.4	40.0	36.0
9			5/6				640	47.1	44.4	40.0

Table 28-55—HE-MCSs for 26-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	24	120	60	4.4	4.2	3.8
1		QPSK	1/2	2		240	120	8.8	8.3	7.5
2			3/4				180	13.2	12.5	11.3
3		16-QAM	1/2	4		480	240	17.6	16.7	15.0
4			3/4				360	26.5	25.0	22.5
5		64-QAM	2/3	6		720	480	35.3	33.3	30.0
6			3/4				540	39.7	37.5	33.8
7			5/6				600	44.1	41.7	37.5
8		256-QAM	3/4	8		960	720	52.9	50.0	45.0
9			5/6				800	58.8	55.6	50.0

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Table 28-56—HE-MCSs for 26-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	24	144	72	5.3	5.0	4.5
1		QPSK	1/2	2		288	144	10.6	10.0	9.0
2			3/4				216	15.9	15.0	13.5
3		16-QAM	1/2	4		576	288	21.2	20.0	18.0
4			3/4				432	31.8	30.0	27.0
5		64-QAM	2/3	6		864	576	42.4	40.0	36.0
6			3/4				648	47.6	45.0	40.5
7			5/6				720	52.9	50.0	45.0
8		256-QAM	3/4	8		1 152	864	63.5	60.0	54.0
9			5/6				960	70.6	66.7	60.0

Table 28-57—HE-MCSs for 26-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	24	168	84	6.2	5.8	5.3
1		QPSK	1/2	2		336	168	12.4	11.7	10.5
2			3/4				252	18.5	17.5	15.8
3		16-QAM	1/2	4		672	336	24.7	23.3	21.0
4			3/4				504	37.1	35.0	31.5
5		64-QAM	2/3	6		1 008	672	49.4	46.7	42.0
6			3/4				756	55.6	52.5	47.3
7			5/6				840	61.8	58.3	52.5
8		256-QAM	3/4	8		1 344	1 008	74.1	70.0	63.0
9			5/6				1 120	82.4	77.8	70.0

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Table 28-58—HE-MCSs for 26-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	24	192	96	7.1	6.7	6.0
1		QPSK	1/2	2		384	192	14.1	13.3	12.0
2			3/4				288	21.2	20.0	18.0
3		16-QAM	1/2	4		768	384	28.2	26.7	24.0
4			3/4				576	42.4	40.0	36.0
5		64-QAM	2/3	6		1 152	768	56.5	53.3	48.0
6			3/4				864	63.5	60.0	54.0
7			5/6				960	70.6	66.7	60.0
8		256-QAM	3/4	8		1 536	1 152	84.7	80.0	72.0
9			5/6				1 280	94.1	88.9	80.0

Table 28-59—HE-MCSs for 52-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	24	24	12	0.9	0.8	0.8
	0		1/2		48	48	24	1.8	1.7	1.5
1	1	QPSK	1/2	2	24	48	24	1.8	1.7	1.5
	0		1/2		48	96	48	3.5	3.3	3.0
2	N/A		3/4		48	96	72	5.3	5.0	4.5
3	1	16-QAM	1/2	4	24	96	48	3.5	3.3	3.0
	0		1/2		48	192	96	7.1	6.7	6.0
4	1		3/4		24	96	72	5.3	5.0	4.5
	0		3/4		48	192	144	10.6	10.0	9.0
5	N/A	64-QAM	2/3	6	48	288	192	14.1	13.3	12.0
6			3/4				216	15.9	15.0	13.5
7			5/6				240	17.6	16.7	15.0
8		256-QAM	3/4	8		384	288	21.2	20.0	18.0
9			5/6				320	23.5	22.2	20.0

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Table 28-60—HE-MCSs for 52-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	24	48	24	1.8	1.7	1.5
	0		1/2		48	96	48	3.5	3.3	3.0
1	1	QPSK	1/2	2	24	96	48	3.5	3.3	3.0
	0		1/2		48	192	96	7.1	6.7	6.0
2	N/A		3/4		48	192	144	10.6	10.0	9.0
3	1	16-QAM	1/2	4	24	192	96	7.1	6.7	6.0
	0		1/2		48	384	192	14.1	13.3	12.0
4	1		3/4		24	192	144	10.6	10.0	9.0
	0		3/4		48	384	288	21.2	20.0	18.0
5	N/A	64-QAM	2/3	6	48	576	384	28.2	26.7	24.0
6			3/4				432	31.8	30.0	27.0
7			5/6				480	35.3	33.3	30.0
8		256-QAM	3/4	8		768	576	42.4	40.0	36.0
9			5/6				640	47.1	44.4	40.0

Table 28-61—HE-MCSs for 52-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	48	144	72	5.3	5.0	4.5
1		QPSK	1/2	2		288	144	10.6	10.0	9.0
2			3/4				216	15.9	15.0	13.5
3		16-QAM	1/2	4		576	288	21.2	20.0	18.0
4			3/4				432	31.8	30.0	27.0
5		64-QAM	2/3	6		864	576	42.4	40.0	36.0
6			3/4				648	47.6	45.0	40.5
7			5/6				720	52.9	50.0	45.0
8		256-QAM	3/4	8		1 152	864	63.5	60.0	54.0
9			5/6				960	70.6	66.7	60.0

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Table 28-62—HE-MCSs for 52-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	48	192	96	7.1	6.7	6.0
1		QPSK	1/2	2		384	192	14.1	13.3	12.0
2			3/4				288	21.2	20.0	18.0
3		16-QAM	1/2	4		768	384	28.2	26.7	24.0
4			3/4				576	42.4	40.0	36.0
5		64-QAM	2/3	6		1 152	768	56.5	53.3	48.0
6			3/4				864	63.5	60.0	54.0
7			5/6				960	70.6	66.7	60.0
8		256-QAM	3/4	8		1 536	1 152	84.7	80.0	72.0
9			5/6				1 280	94.1	88.9	80.0

Table 28-63—HE-MCSs for 52-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	48	240	120	8.8	8.3	7.5
1		QPSK	1/2	2		480	240	17.6	16.7	15.0
2			3/4				360	26.5	25.0	22.5
3		16-QAM	1/2	4		960	480	35.3	33.3	30.0
4			3/4				720	52.9	50.0	45.0
5		64-QAM	2/3	6		1 440	960	70.6	66.7	60.0
6			3/4				1080	79.4	75.0	67.5
7			5/6				1 200	88.2	83.3	75.0
8		256-QAM	3/4	8		1 920	1 440	105.9	100.0	90.0
9			5/6				1 600	117.6	111.1	100.0

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Table 28-64—HE-MCSs for 52-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	48	288	144	10.6	10.0	9.0
1		QPSK	1/2	2		576	288	21.2	20.0	18.0
2			3/4				432	31.8	30.0	27.0
3		16-QAM	1/2	4		1 152	576	42.4	40.0	36.0
4			3/4				864	63.5	60.0	54.0
5		64-QAM	2/3	6		1 728	1 152	84.7	80.0	72.0
6			3/4				1 296	95.3	90.0	81.0
7			5/6				1 440	105.9	100.0	90.0
8		256-QAM	3/4	8		2 304	1 728	127.1	120.0	108.0
9			5/6				1 920	141.2	133.3	120.0

Table 28-65—HE-MCSs for 52-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	48	336	168	12.4	11.7	10.5
1		QPSK	1/2	2		672	336	24.7	23.3	21.0
2			3/4				504	37.1	35.0	31.5
3		16-QAM	1/2	4		1 344	672	49.4	46.7	42.0
4			3/4				1 008	74.1	70.0	63.0
5		64-QAM	2/3	6		2 016	1 344	98.8	93.3	84.0
6			3/4				1 512	111.2	105.0	94.5
7			5/6				1 680	123.5	116.7	105.0
8		256-QAM	3/4	8		2 688	2 016	148.2	140.0	126.0
9			5/6				2 240	164.7	155.6	140.0

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Table 28-66—HE-MCSs for 52-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	48	384	192	14.1	13.3	12.0
1		QPSK	1/2	2		768	384	28.2	26.7	24.0
2			3/4				576	42.4	40.0	36.0
3		16-QAM	1/2	4		1 536	768	56.5	53.3	48.0
4			3/4				1 152	84.7	80.0	72.0
5		64-QAM	2/3	6		2 304	1 536	112.9	106.7	96.0
6			3/4				1 728	127.1	120.0	108.0
7			5/6				1 920	141.2	133.3	120.0
8		256-QAM	3/4	8		3 072	2 304	169.4	160.0	144.0
9			5/6				2 560	188.2	177.8	160.0

Table 28-67—HE-MCSs for 106-tone RU, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	51	51	25	1.8	1.7	1.6
	0		1/2		102	102	51	3.8	3.5	3.2
1	1	QPSK	1/2	2	51	102	51	3.8	3.5	3.2
	0		1/2		102	204	102	7.5	7.1	6.4
2	N/A		3/4		102	204	153	11.3	10.6	9.6
3	1	16-QAM	1/2	4	51	204	102	7.5	7.1	6.4
	0		1/2		102	408	204	15.0	14.2	12.8
4	1		3/4		51	204	153	11.3	10.6	9.6
	0		3/4		102	408	306	22.5	21.3	19.1
5	N/A	64-QAM	2/3	6	102	612	408	30.0	28.3	25.5
6			3/4		102		459	33.8	31.9	28.7
7			5/6		102		510	37.5	35.4	31.9
8		256-QAM	3/4	8	102	816	612	45.0	42.5	38.3
9			5/6		102		680	50.0	47.2	42.5

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Table 28-68—HE-MCSs for 106-tone RU, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	51	102	51	3.8	3.5	3.2
	0		1/2		102	204	102	7.5	7.1	6.4
1	1	QPSK	1/2	2	51	204	102	7.5	7.1	6.4
	0		1/2		102	408	204	15.0	14.2	12.8
2	N/A		3/4		102	408	306	22.5	21.3	19.1
3	1	16-QAM	1/2	4	51	408	204	15.0	14.2	12.8
	0		1/2		102	816	408	30.0	28.3	25.5
4	1		3/4		51	408	306	22.5	21.3	19.1
	0		3/4		102	816	612	45.0	42.5	38.3
5	N/A	64-QAM	2/3	6	102	1 224	816	60.0	56.7	51.0
6			3/4		102		918	67.5	63.8	57.4
7			5/6		102		1 020	75.0	70.8	63.8
8		256-QAM	3/4	8	102	1 632	1 224	90.0	85.0	76.5
9			5/6		102		1 360	100.0	94.4	85.0

Table 28-69—HE-MCSs for 106-tone RU, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	102	306	153	11.3	10.6	9.6
1		QPSK	1/2	2		612	306	22.5	21.3	19.1
2			3/4				459	33.8	31.9	28.7
3		16-QAM	1/2	4		1 224	612	45.0	42.5	38.3
4			3/4				918	67.5	63.8	57.4
5		64-QAM	2/3	6		1 836	1 224	90.0	85.0	76.5
6			3/4				1 377	101.3	95.6	86.1
7			5/6				1 530	112.5	106.3	95.6
8		256-QAM	3/4	8		2 448	1 836	135.0	127.5	114.8
9			5/6				2 040	150.0	141.7	127.5

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Table 28-70—HE-MCSs for 106-tone RU, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	102	408	204	15.0	14.2	12.8
1		QPSK	1/2	2		816	408	30.0	28.3	25.5
2			3/4				612	45.0	42.5	38.3
3		16-QAM	1/2	4		1 632	816	60.0	56.7	51.0
4			3/4				1 224	90.0	85.0	76.5
5		64-QAM	2/3	6		2 448	1 632	120.0	113.3	102.0
6			3/4				1 836	135.0	127.5	114.8
7			5/6				2 040	150.0	141.7	127.5
8		256-QAM	3/4	8		3 264	2 448	180.0	170.0	153.0
9			5/6				2 720	200.0	188.9	170.0

Table 28-71—HE-MCSs for 106-tone RU, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	102	510	255	18.8	17.7	15.9
1		QPSK	1/2	2		1 020	510	37.5	35.4	31.9
2			3/4				765	56.3	53.1	47.8
3		16-QAM	1/2	4		2 040	1 020	75.0	70.8	63.8
4			3/8				1 530	112.5	106.3	95.6
5		64-QAM	2/3	6		3 060	2 040	150.0	141.7	127.5
6			3/4				2 295	168.8	159.4	143.4
7			5/6				2 550	187.5	177.1	159.4
8		256-QAM	3/4	8		4 080	3 060	225.0	212.5	191.3
9			5/6				3 400	250.0	236.1	212.5

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Table 28-72—HE-MCSs for 106-tone RU, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	102	612	306	22.5	21.3	19.1
1		QPSK	1/2	2		1 224	612	45.0	42.5	38.3
2			3/4				918	67.5	63.8	57.4
3		16-QAM	1/2	4		2 448	1 224	90.0	85.0	76.5
4			3/4				1 836	135.0	127.5	114.8
5		64-QAM	2/3	6		3 672	2 448	180.0	170.0	153.0
6			3/4				2 754	202.5	191.3	172.1
7			5/6				3 060	225.0	212.5	191.3
8		256-QAM	3/4	8		4 896	3 672	270.0	255.0	229.5
9			5/6				4 080	300.0	283.3	255.0

Table 28-73—HE-MCSs for 106-tone RU, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	102	714	357	26.3	24.8	22.3
1		QPSK	1/2	2		1 428	714	52.5	49.6	44.6
2			3/4				1 071	78.8	74.4	66.9
3		16-QAM	1/2	4		2 856	1 428	105.0	99.2	89.3
4			3/4				2 142	157.5	148.8	133.9
5		64-QAM	2/3	6		4 284	2 856	210.0	198.3	178.5
6			3/4				3 213	236.3	223.1	200.8
7			5/6				3 570	262.5	247.9	223.1
8		256-QAM	3/4	8		5 712	4 284	315.0	297.5	267.8
9			5/6				4 760	350.0	330.6	297.5

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Table 28-74—HE-MCSs for 106-tone RU, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	102	816	408	30.0	28.3	25.5
1		QPSK	1/2	2		1632	816	60.0	56.7	51.0
2			3/4				1 224	90.0	85.0	76.5
3		16-QAM	1/2	4		3264	1 632	120.0	113.3	102.0
4			3/4				2 448	180.0	170.0	153.0
5		64-QAM	2/3	6		4896	3 264	240.0	226.7	204.0
6			3/4				3 672	270.0	225.0	229.5
7			5/6				4 080	300.0	283.3	255.0
8		256-QAM	3/4	8		6528	4 896	360.0	340.0	306.0
9			5/6				5 440	400.0	377.8	340.0

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Table 28-75—HE-MCSs for 242-tone RU and non-OFDMA 20 MHz, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	117	117	58	4.3	4.0	3.6
	0		1/2		234	234	117	8.6	8.1	7.3
1	1	QPSK	1/2	2	117	234	117	8.6	8.1	7.3
	0		1/2		234	468	234	17.2	16.3	14.6
2	N/A		3/4		234	468	351	25.8	24.4	21.9
3	1	16-QAM	1/2	4	117	468	234	17.2	16.3	14.6
	0		1/2		234	936	468	34.4	32.5	29.3
4	1		3/4		117	468	351	25.8	24.4	21.9
	0		3/4		234	936	702	51.6	48.8	43.9
5	N/A	64-QAM	2/3	6	234	1 404	936	68.8	65.0	58.5
6			3/4				1 053	77.4	73.1	65.8
7			5/6				1 170	86.0	81.3	73.1
8		256-QAM	3/4	8		1 872	1 404	103.2	97.5	87.8
9			5/6				1 560	114.7	108.3	97.5
10		1024-QAM	3/4	10		2 340	1 755	129.0	121.9	109.7
11			5/6				1 950	143.4	135.4	121.9

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Table 28-76—HE-MCSs for 242-tone RU and non-OFDMA 20 MHz, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	117	234	117	8.6	8.1	7.3
	0		1/2		234	468	234	17.2	16.3	14.6
1	1	QPSK	1/2	2	117	468	234	17.2	16.3	14.6
	0		1/2		234	936	468	34.4	32.5	29.3
2	N/A		3/4		234	936	702	51.6	48.8	43.9
3	1	16-QAM	1/2	4	117	936	468	34.4	32.5	29.3
	0		1/2		234	1 872	936	68.8	65.0	58.5
4	1		3/4		117	936	702	51.6	48.8	43.9
	0		3/4		234	1 872	1 404	103.2	97.5	87.8
5	N/A	64-QAM	2/3	6	234	2 808	1 872	137.6	130.0	117.0
6			3/4				2 106	154.9	146.3	131.6
7			5/6				2 340	172.1	162.5	146.3
8		256-QAM	3/4	8		3 744	2 808	206.5	195.0	175.5
9			5/6				3 120	229.4	216.7	195.0
10		1024-QAM	3/4	10		4 680	3 510	258.1	243.8	219.4
11			5/6				3 900	286.8	270.8	243.8

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Table 28-77—HE-MCSs for 242-tone RU and non-OFDMA 20 MHz, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	234	702	351	25.8	24.4	21.9
1		QPSK	1/2	2		1 404	702	51.6	48.8	43.9
2			3/4				1 053	77.4	73.1	65.8
3		16-QAM	1/2	4		2 808	1 404	103.2	97.5	87.8
4			3/4				2 106	154.9	146.3	131.6
5		64-QAM	2/3	6		4 212	2 808	206.5	195.0	175.5
6			3/4				3 159	232.3	219.4	197.4
7			5/6				3 510	258.1	243.8	219.4
8		256-QAM	3/4	8		5 616	4 212	309.7	292.5	263.3
9			5/6				4 680	344.1	325.0	292.5
10		1024-QAM	3/4	10		7 020	5 265	387.1	365.6	329.1
11			5/6				5 850	430.1	406.3	365.6

Table 28-78—HE-MCSs for 242-tone RU and non-OFDMA 20 MHz, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	234	936	468	34.4	32.5	29.3
1		QPSK	1/2	2		1 872	936	68.8	65.0	58.5
2			3/4				1 404	103.2	97.5	87.8
3		16-QAM	1/2	4		3 744	1 872	137.6	130.0	117.0
4			3/4				2 808	206.5	195.0	175.5
5		64-QAM	2/3	6		5 616	3 744	275.3	260.0	234.0
6			3/4				4 212	309.7	292.5	263.3
7			5/6				4 680	344.1	325.0	292.5
8		256-QAM	3/4	8		7 488	5 616	412.9	390.0	351.0
9			5/6				6 240	458.8	433.3	390.0
10		1024-QAM	3/4	10		9 360	7 020	516.2	487.5	438.8
11			5/6				7 800	573.5	541.7	487.5

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Table 28-79—HE-MCSs for 242-tone RU and non-OFDMA 20 MHz, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	234	1 170	585	43.0	40.6	36.6
1		QPSK	1/2	2		2 340	1 170	86.0	81.3	73.1
2			3/4				1 755	129.0	121.9	109.7
3		16-QAM	1/2	4		4 680	2 340	172.1	162.5	146.3
4			3/4				3 510	258.1	243.8	219.4
5		64-QAM	2/3	6		7 020	4 680	344.1	325.0	292.5
6			3/4				5 265	387.1	365.6	329.1
7			5/6				5 850	430.1	406.3	365.6
8		256-QAM	3/4	8		9 360	7 020	516.2	487.5	438.8
9			5/6				7 800	573.5	541.7	487.5
10		1024-QAM	3/4	10		11 700	8 775	645.2	609.4	548.4
11			5/6				9 750	716.9	677.1	609.4

Table 28-80—HE-MCSs for 242-tone RU and non-OFDMA 20 MHz, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	234	1 404	702	51.6	48.8	43.9
1		QPSK	1/2	2		2 808	1 404	103.2	97.5	87.8
2			3/4				2 106	154.9	146.3	131.6
3		16-QAM	1/2	4		5 616	2 808	206.5	195.0	175.5
4			3/4				4 212	309.7	292.5	263.3
5		64-QAM	2/3	6		8 424	5 616	412.9	390.0	351.0
6			3/4				6 318	464.6	438.8	394.9
7			5/6				7 020	516.2	487.5	438.8
8		256-QAM	3/4	8		11 232	8 424	619.4	585.0	526.5
9			5/6				9 360	688.2	650.0	585.0
10		1024-QAM	3/4	10		14 040	10 530	774.3	731.3	658.1
11			5/6				11 700	860.3	812.5	731.3

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Table 28-81—HE-MCSs for 242-tone RU and non-OFDMA 20 MHz, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	234	1 638	819	60.2	56.9	51.2
1		QPSK	1/2	2		3 276	1 638	120.4	113.8	102.4
2			3/4				2 457	180.7	170.6	153.6
3		16-QAM	1/2	4		6 552	3 276	240.9	227.5	204.8
4			3/4				4 914	361.3	341.3	307.1
5		64-QAM	2/3	6		9 828	6 552	481.8	455.0	409.5
6			3/4				7 371	542.0	511.9	460.7
7			5/6				8 190	602.2	568.8	511.9
8		256-QAM	3/4	8		13 104	9 828	722.6	682.5	614.3
9			5/6				10 920	802.9	758.3	682.5
10		1024-QAM	3/4	10		16 380	12 285	903.3	853.1	767.8
11			5/6				13 650	1 003.7	947.9	853.1

Table 28-82—HE-MCSs for 242-tone RU and non-OFDMA 20 MHz, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	234	1 872	936	68.8	65.0	58.5
1		QPSK	1/2	2		3 744	1 872	137.6	130.0	117.0
2			3/4				2 808	206.5	195.0	175.5
3		16-QAM	1/2	4		7 488	3 744	275.3	260.0	234.0
4			3/4				5 616	412.9	390.0	351.0
5		64-QAM	2/3	6		11 232	7 488	550.6	520.0	468.0
6			3/4				8 424	619.4	585.0	526.5
7			5/6				9 360	688.2	650.0	585.0
8		256-QAM	3/4	8		14 976	11 232	825.9	780.0	702.0
9			5/6				12 480	917.6	866.7	780.0
10		1024-QAM	3/4	10		18 720	14 040	1 032.4	975.0	877.5
11			5/6				15 600	1 147.1	1 083.3	975.0

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Table 28-83—HE-MCSs for 484-tone RU and non-OFDMA 40 MHz, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	234	234	117	8.6	8.1	7.3
	0		1/2		468	468	234	17.2	16.3	14.6
1	1	QPSK	1/2	2	234	468	234	17.2	16.3	14.6
	0		1/2		468	936	468	34.4	32.5	29.3
2	N/A		3/4		468	936	702	51.6	48.8	43.9
3	1	16-QAM	1/2	4	234	936	468	34.4	32.5	29.3
	0		1/2		468	1 872	936	68.8	65.0	58.5
4	1		3/4		234	936	702	51.6	48.8	43.9
	0		3/4		468	1 872	1 404	103.2	97.5	87.8
5	N/A	64-QAM	2/3	6	468	2 808	1 872	137.6	130.0	117.0
6			3/4				2 106	154.9	146.3	131.6
7			5/6				2 340	172.1	162.5	146.3
8		256-QAM	3/4	8		3 744	2 808	206.5	195.0	175.5
9			5/6				3 120	229.4	216.7	195.0
10		1024-QAM	3/4	10		4 680	3 510	258.1	243.8	219.4
11			5/6				3 900	286.8	270.8	243.8

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Table 28-84—HE-MCSs for 484-tone RU and non-OFDMA 40 MHz, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	234	468	234	17.2	16.3	14.6
	0		1/2		468	936	468	34.4	32.5	29.3
1	1	QPSK	1/2	2	234	936	468	34.4	32.5	29.3
	0		1/2		468	1 872	936	68.8	65.0	58.5
2	N/A		3/4		468	1 872	1 404	103.2	97.5	87.8
3	1	16-QAM	1/2	4	234	1 872	936	68.8	65.0	58.5
	0		1/2		468	3 744	1 872	137.6	130.0	117.0
4	1		3/4		234	1 872	1 404	103.2	97.5	87.8
	0		3/4		468	3 744	2 808	206.5	195.0	175.5
5	N/A	64-QAM	2/3	6	468	5 616	3 744	275.3	260.0	234.0
6			3/4				4 212	309.7	292.5	263.3
7			5/6				4 680	344.1	325.0	292.5
8		256-QAM	3/4	8		7 488	5 616	412.9	390.0	351.0
9			5/6				6 240	458.8	433.3	390.0
10		1024-QAM	3/4	10		9 360	7 020	516.2	487.5	438.8
11			5/6				7 800	573.5	541.7	487.5

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Table 28-85—HE-MCSs for 484-tone RU and non-OFDMA 40 MHz, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	468	1 404	702	51.6	48.8	43.9
1		QPSK	1/2	2		2 808	1 404	103.2	97.5	87.8
2			3/4				2 106	154.9	146.3	131.6
3		16-QAM	1/2	4		5 616	2 808	206.5	195.0	175.5
4			3/4				4 212	309.7	292.5	263.3
5		64-QAM	2/3	6		8 424	5 616	412.9	390.0	351.0
6			3/4				6 318	464.6	438.8	394.9
7			5/6				7 020	516.2	487.5	438.8
8		256-QAM	3/4	8		11 232	8 424	619.4	585.0	526.5
9			5/6				9 360	688.2	650.0	585.0
10		1024-QAM	3/4	10		14 040	10 530	774.3	731.3	658.1
11			5/6				11 700	860.3	812.5	731.3

Table 28-86—HE-MCSs for 484-tone RU and non-OFDMA 40 MHz, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	468	1 872	936	68.8	65.0	58.5
1		QPSK	1/2	2		3 744	1 872	137.6	130.0	117.0
2			3/4				2 808	206.5	195.0	175.5
3		16-QAM	1/2	4		7 488	3 744	275.3	260.0	234.0
4			3/4				5 616	412.9	390.0	351.0
5		64-QAM	2/3	6		11 232	7 488	550.6	520.0	468.0
6			3/4				8 424	619.4	585.0	526.5
7			5/6				9 360	688.2	650.0	585.0
8		256-QAM	3/4	8		14 976	11 232	825.9	780.0	702.0
9			5/6				12 480	917.6	866.7	780.0
10		1024-QAM	3/4	10		18 720	14 040	1 032.4	975.0	877.5
11			5/6				15 600	1 147.1	1 083.3	975.0

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Table 28-87—HE-MCSs for 484-tone RU and non-OFDMA 40 MHz, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	468	2 340	1 170	86.0	81.3	73.1
1		QPSK	1/2	2		4 680	2 340	172.1	162.5	146.3
2			3/4				3 510	258.1	243.8	219.4
3		16-QAM	1/2	4		9 360	4 680	344.1	325.0	292.5
4			3/8				7 020	516.2	487.5	438.8
5		64-QAM	2/3	6		14 040	9 360	688.2	650.0	585.0
6			3/4				10 530	774.3	731.3	658.1
7			5/6				11 700	860.3	812.5	731.3
8		256-QAM	3/4	8		18 720	14 040	1 032.4	975.0	877.5
9			5/6				15 600	1 147.1	1 083.3	975.0
10		1024-QAM	3/4	10		23 400	17 550	1 290.4	1 218.8	1 096.9
11			5/6				19 500	1 433.8	1 354.2	1 218.8

Table 28-88—HE-MCSs for 484-tone RU and non-OFDMA 40 MHz, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	468	2 808	1404	103.2	97.5	87.8
1		QPSK	1/2	2		5 616	2808	206.5	195.0	175.5
2			3/4				4212	309.7	292.5	263.3
3		16-QAM	1/2	4		11 232	5616	412.9	390.0	351.0
4			3/4				8424	619.4	585.0	526.5
5		64-QAM	2/3	6		16 848	11 232	825.9	780.0	702.0
6			3/4				12 636	929.1	877.5	789.8
7			5/6				14 040	1 032.4	975.0	877.5
8		256-QAM	3/4	8		22 464	16 848	1 238.8	1 170.0	1 053.0
9			5/6				18 720	1 376.5	1 300.0	1 170.0
10		1024-QAM	3/4	10		28 080	21 060	1 548.5	1 462.5	1 316.3
11			5/6				23 400	1 720.6	1 625.0	1 462.5

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Table 28-89—HE-MCSs for 484-tone RU and non-OFDMA 40 MHz, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	468	3 276	1 638	120.4	113.8	102.4
1		QPSK	1/2	2		6 552	3 276	240.9	227.5	204.8
2			3/4				4 914	361.3	341.3	307.1
3		16-QAM	1/2	4		13 104	6 552	481.8	455.0	409.5
4			3/4				9 828	722.6	682.5	614.3
5		64-QAM	2/3	6		19 656	13 104	963.5	910.0	819.0
6			3/4				14 742	1 084.0	1 023.8	921.4
7			5/6				16 380	1 204.4	1 137.5	1 023.8
8		256-QAM	3/4	8		26 208	19 656	1 445.3	1 365.0	1 228.5
9			5/6				21 840	1 605.9	1 516.7	1 365.0
10		1024-QAM	3/4	10		32 760	24 570	1 806.6	1 706.3	1 535.6
11			5/6				27 300	2 007.4	1 895.8	1 706.3

Table 28-90—HE-MCSs for 484-tone RU and non-OFDMA 40 MHz, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	468	3 744	1 872	137.6	130.0	117.0
1		QPSK	1/2	2		7 488	3 744	275.3	260.0	234.0
2			3/4				5 616	412.9	390.0	351.0
3		16-QAM	1/2	4		14 976	7 488	550.6	520.0	468.0
4			3/4				11 232	825.9	780.0	702.0
5		64-QAM	2/3	6		22 464	14 976	1 101.2	1 040.0	936.0
6			3/4				16 848	1 238.8	1 170.0	1 053.0
7			5/6				18 720	1 376.5	1 300.0	1 170.0
8		256-QAM	3/4	8		29 952	22 464	1 651.8	1 560.0	1 404.0
9			5/6				24 960	1 835.3	1 733.3	1 560.0
10		1024-QAM	3/4	10		37 440	28 080	2 064.7	1 950.0	1 755.0
11			5/6				31 200	2 294.1	2 166.7	1 950.0

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Table 28-91—HE-MCSs for 996-tone RU and non-OFDMA 80 MHz, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	490	490	245	18.0	17.0	15.3
	0		1/2		980	980	490	36.0	34.0	30.6
1	1	QPSK	1/2	2	490	980	490	36.0	34.0	30.6
	0		1/2		980	1960	980	72.1	68.1	61.3
2	N/A		3/4		980	1960	1 470	108.1	102.1	91.9
3	1	16-QAM	1/2	4	490	1960	980	72.1	68.1	61.3
	0		1/2		980	3920	1 960	144.1	136.1	122.5
4	1		3/4		490	1960	1 470	108.1	102.1	91.9
	0		3/4		980	3920	2 940	216.2	204.2	183.8
5	N/A	64-QAM	2/3	6	980	5 880	3 920	288.2	272.2	245.0
6			3/4				4 410	324.3	306.3	275.6
7			5/6				4 900	360.3	340.3	306.3
8		256-QAM	3/4	8		7 840	5 880	432.4	408.3	367.5
9			5/6				6 533	480.4	453.7	408.3
10		1024-QAM	3/4	10		9 800	7 350	540.4	510.4	459.4
11			5/6				8 166	600.4	567.1	510.4

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Table 28-92—HE-MCSs for 996-tone RU and non-OFDMA 80 MHz, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	490	980	490	36.0	34.0	30.6
	0		1/2		980	1 960	980	72.1	68.1	61.3
1	1	QPSK	1/2	2	490	1 960	980	72.1	68.1	61.3
	0		1/2		980	3 920	1 960	144.1	136.1	122.5
2	N/A		3/4		980	3 920	2 940	216.2	204.2	183.8
3	1	16-QAM	1/2	4	490	3 920	1 960	144.1	136.1	122.5
	0		1/2		980	7 840	3 920	288.2	272.2	245.0
4	1		3/4		490	3 920	2 940	216.2	204.2	183.8
	0		3/4		980	7 840	5 880	432.4	408.3	367.5
5	N/A	64-QAM	2/3	6	980	11 760	7 840	576.5	544.4	490.0
6			3/4				8 820	648.5	612.5	551.3
7			5/6				9 800	720.6	680.6	612.5
8		256-QAM	3/4	8		15 680	11 760	864.7	816.7	735.0
9			5/6				13 066	960.7	907.4	816.6
10		1024-QAM	3/4	10		19 600	14 700	1 080.9	1 020.8	918.8
11			5/6				16 333	1 201.0	1 134.3	1 020.8

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Table 28-93—HE-MCSs for 996-tone RU and non-OFDMA 80 MHz, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	980	2 940	1 470	108.1	102.1	91.9
1		QPSK	1/2	2		5 880	2 940	216.2	204.2	183.8
2			3/4				4 410	324.3	306.3	275.6
3		16-QAM	1/2	4		11 760	5 880	432.4	408.3	367.5
4			3/4				8 820	648.5	612.5	551.3
5		64-QAM	2/3	6		17 640	11 760	864.7	816.7	735.0
6			3/4				13 230	972.8	918.8	826.9
7			5/6				14 700	1 080.9	1 020.8	918.8
8		256-QAM	3/4	8		23 520	17 640	1 297.1	1 225.0	1 102.5
9			5/6				19 600	1 441.2	1 361.1	1 225.0
10		1024-QAM	3/4	10		29 400	22 050	1 621.3	1 531.3	1 378.1
11			5/6				24 500	1 801.5	1 701.4	1 531.3

Table 28-94—HE-MCSs for 996-tone RU and non-OFDMA 80 MHz, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	980	3 920	1 960	144.1	136.1	122.5
1		QPSK	1/2	2		7 840	3 920	288.2	272.2	245.0
2			3/4				5 880	432.4	408.3	367.5
3		16-QAM	1/2	4		15 680	7 840	576.5	544.4	490.0
4			3/4				11 760	864.7	816.7	735.0
5		64-QAM	2/3	6		23 520	15 680	1 152.9	1 088.9	980.0
6			3/4				17 640	1 297.1	1 225.0	1 102.5
7			5/6				19 600	1 441.2	1 361.1	1 225.0
8		256-QAM	3/4	8		31 360	23 520	1 729.4	1 633.3	1 470.0
9			5/6				26 133	1 921.5	1 814.8	1 633.3
10		1024-QAM	3/4	10		39 200	29 400	2 161.8	2 041.7	1 837.5
11			5/6				32 666	2 401.9	2 268.5	2 041.6

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Table 28-95—HE-MCSs for 996-tone RU and non-OFDMA 80 MHz, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	980	4 900	2 450	180.1	170.1	153.1
1		QPSK	1/2	2		9 800	4 900	360.3	340.3	306.3
2			3/4				7 350	540.4	510.4	459.4
3		16-QAM	1/2	4		19 600	9 800	720.6	680.6	612.5
4			3/8				14 700	1 080.9	1 020.8	918.8
5		64-QAM	2/3	6		29 400	19 600	1 441.2	1 361.1	1 225.0
6			3/4				22 050	1 621.3	1 531.3	1 378.1
7			5/6				24 500	1 801.5	1 701.4	1 531.3
8		256-QAM	3/4	8		39 200	29 400	2 161.8	2 041.7	1 837.5
9			5/6				32 666	2 401.9	2 268.5	2 041.6
10		1024-QAM	3/4	10		49 000	36 750	2 702.2	2 552.1	2 296.9
11			5/6				40 833	3 002.4	2 835.6	2 552.1

Table 28-96—HE-MCSs for 996-tone RU and non-OFDMA 80 MHz, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	980	5 880	2 940	216.2	204.2	183.8
1		QPSK	1/2	2		11 760	5 880	432.4	408.3	367.5
2			3/4				8 820	648.5	612.5	551.3
3		16-QAM	1/2	4		23 520	11 760	864.7	816.7	735.0
4			3/4				17 640	1 297.1	1 225.0	1 102.5
5		64-QAM	2/3	6		35 280	23 520	1 729.4	1 633.3	1 470.0
6			3/4				26 460	1 945.6	1 837.5	1 653.8
7			5/6				29 400	2 161.8	2 041.7	1 837.5
8		256-QAM	3/4	8		47 040	35 280	2 594.1	2 450.0	2 205.0
9			5/6				39 200	2 882.4	2 722.2	2 450.0
10		1024-QAM	3/4	10		58 800	44 100	3 242.6	3 062.5	2 756.3
11			5/6				49 000	3 602.9	3 402.8	3 062.5

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Table 28-97—HE-MCSs for 996-tone RU and non-OFDMA 80 MHz, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	980	6 860	3 430	252.2	238.2	214.4
1		QPSK	1/2	2		13 720	6 860	504.4	476.4	428.8
2			3/4				10 290	756.6	714.6	643.1
3		16-QAM	1/2	4		27 440	13 720	1 008.8	952.8	857.5
4			3/4				20 580	1 513.2	1 429.2	1 286.3
5		64-QAM	2/3	6		41 160	27 440	2 017.6	1 905.6	1 715.0
6			3/4				30 870	2 269.9	2 143.8	1 929.4
7			5/6				34 300	2 522.1	2 381.9	2 143.8
8		256-QAM	3/4	8		54 880	41 160	3 026.5	2 858.3	2 572.5
9			5/6				45 733	3 362.7	3 175.9	2 858.3
10		1024-QAM	3/4	10		68 600	51 450	3 783.1	3 572.9	3 215.6
11			5/6				57 166	4 203.4	3 969.9	3 572.9

Table 28-98—HE-MCSs for 996-tone RU and non-OFDMA 80 MHz, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	980	7 840	3 920	288.2	272.2	245.0
1		QPSK	1/2	2		15 680	7 840	576.5	544.4	490.0
2			3/4				11 760	864.7	816.7	735.0
3		16-QAM	1/2	4		31 360	15 680	1 152.9	1 088.9	980.0
4			3/4				23 520	1 729.4	1 633.3	1 470.0
5		64-QAM	2/3	6		47 040	31 360	2 305.9	2 177.8	1 960.0
6			3/4				35 280	2 594.1	2 450.0	2 205.0
7			5/6				39 200	2 882.4	2 722.2	2 450.0
8		256-QAM	3/4	8		62 720	47 040	3 458.8	3 266.7	2 940.0
9			5/6				52 266	3 843.1	3 629.6	3 266.6
10		1024-QAM	3/4	10		78 400	58 800	4 323.5	4 083.3	3 675.0
11			5/6				65 333	4 803.9	4 537.0	4 083.3

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Table 28-99—HE-MCSs for non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	980	980	490	36.0	34.0	30.6
	0		1/2		1 960	1 960	980	72.1	68.1	61.3
1	1	QPSK	1/2	2	980	1 960	980	72.1	68.1	61.3
	0		1/2		1 960	3 920	1 960	144.1	136.1	122.5
2	N/A		3/4		1 960	3 920	2 940	216.2	204.2	183.8
3	1	16-QAM	1/2	4	980	3 920	1 960	144.1	136.1	122.5
	0		1/2		1 960	7 840	3 920	288.2	272.2	245.0
4	1		3/4		980	3 920	2 940	216.2	204.2	183.8
	0		3/4		1 960	7 840	5 880	432.4	408.3	367.5
5	N/A	64-QAM	2/3	6	1 960	11 760	7 840	576.5	544.4	490.0
6			3/4				8 820	648.5	612.5	551.3
7			5/6				9 800	720.6	680.6	612.5
8		256-QAM	3/4	8		15 680	11 760	864.7	816.7	735.0
9			5/6				13 066	960.7	907.4	816.6
10		1024-QAM	3/4	10		19 600	14 700	1 080.9	1 020.8	918.8
11			5/6				16 333	1 201.0	1 134.2	1 020.8

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Table 28-100—HE-MCSs for non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	1	BPSK	1/2	1	980	1 960	980	72.1	68.1	61.3
	0		1/2		1 960	3 920	1 960	144.1	136.1	122.5
1	1	QPSK	1/2	2	980	3 920	1 960	144.1	136.1	122.5
	0		1/2		1 960	7 840	3 920	288.2	272.2	245.0
2	N/A		3/4		1 960	7 840	5 880	432.4	408.3	367.5
3	1	16-QAM	1/2	4	980	7 840	3 920	288.2	272.2	245.0
	0		1/2		1 960	15 680	7 840	576.5	544.4	490.0
4	1		3/4		980	7 840	5 880	432.4	408.3	367.5
	0		3/4		1 960	15 680	11 760	864.7	816.7	735.0
5	N/A	64-QAM	2/3	6	1 960	23 520	15 680	1 152.9	1 088.9	980.0
6			3/4				17 640	1 297.1	1 225.0	1 102.5
7			5/6				19 600	1 441.2	1 361.1	1 225.0
8		256-QAM	3/4	8		31 360	23 520	1 729.4	1 633.3	1 470.0
9			5/6				26 133	1 921.5	1 814.8	1 633.3
10		1024-QAM	3/4	10		39 200	29 400	2 161.8	2 041.7	1 837.5
11			5/6				32 666	2 401.9	2 268.5	2 041.6

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Table 28-101—HE-MCSs for non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	1 960	5 880	2 940	216.2	204.2	183.8
1		QPSK	1/2	2		11 760	5 880	432.4	408.3	367.5
2			3/4				8 820	648.5	612.5	551.3
3		16-QAM	1/2	4		23 520	11 760	864.7	816.7	735.0
4			3/4				17 640	1 297.1	1 225.0	1 102.5
5		64-QAM	2/3	6		35 280	23 520	1 729.4	1 633.3	1 470.0
6			3/4				26 460	1 945.6	1 837.5	1 653.8
7			5/6				29 400	2 161.8	2 041.7	1 837.5
8		256-QAM	3/4	8		47 040	35 280	2 594.1	2 450.0	2 205.0
9			5/6				39 200	2 882.4	2 722.2	2 450.0
10		1024-QAM	3/4	10		58 800	44 100	3 242.6	3 062.5	2 756.3
11			5/6				49 000	3 602.9	3 402.8	3 062.5

Table 28-102—HE-MCSs for non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	1 960	7 840	3 920	288.2	272.2	245.0
1		QPSK	1/2	2		15 680	7 840	576.5	544.4	490.0
2			3/4				11 760	864.7	816.7	735.0
3		16-QAM	1/2	4		31 360	15 680	1 152.9	1 088.9	980.0
4			3/4				23 520	1 729.4	1 633.3	1 470.0
5		64-QAM	2/3	6		47 040	31 360	2 305.9	2 177.8	1 960.0
6			3/4				35 280	2 594.1	2 450.0	2 205.0
7			5/6				39 200	2 882.4	2 722.2	2 450.0
8		256-QAM	3/4	8		62 720	47 040	3 458.8	3 266.7	2 940.0
9			5/6				52 266	3 843.1	3 629.6	3 266.6
10		1024-QAM	3/4	10		78 400	58 800	4 323.5	4 083.3	3 675.0
11			5/6				65 333	4 803.9	4 537.0	4 083.3

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Table 28-103—HE-MCSs for non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	1 960	9 800	4 900	360.3	340.3	306.3
1		QPSK	1/2	2		19 600	9 800	720.6	680.6	612.5
2			3/4				14 700	1 080.9	1 020.8	918.8
3		16-QAM	1/2	4		39 200	19 600	1 441.2	1 361.1	1 225.0
4			3/4				29 400	2 161.8	2 041.7	1 837.5
5		64-QAM	2/3	6		58 800	39 200	2 882.4	2 722.2	2 450.0
6			3/4				44 100	3 242.6	3 062.5	2 756.3
7			5/6				49 000	3 602.9	3 402.8	3 062.5
8		256-QAM	3/4	8		78 400	58 800	4 323.5	4 083.3	3 675.0
9			5/6				65 333	4 803.9	4 537.0	4 083.3
10		1024-QAM	3/4	10		98 000	73 500	5 404.4	5 104.2	4 593.8
11			5/6				81 666	6 004.9	5 671.3	5 104.1

Table 28-104—HE-MCSs for non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	1 960	11 760	5 880	432.4	408.3	367.5
1		QPSK	1/2	2		23 520	11 760	864.7	816.7	735.0
2			3/4				17 640	1 297.1	1 225.0	1 102.5
3		16-QAM	1/2	4		47 040	23 520	1 729.4	1 633.3	1 470.0
4			3/4				35 280	2 594.1	2 450.0	2 205.0
5		64-QAM	2/3	6		70 560	47 040	3 458.8	3 266.7	2 940.0
6			3/4				52 920	3 891.2	3 675.0	3 307.5
7			5/6				58 800	4 323.5	4 083.3	3 675.0
8		256-QAM	3/4	8		94 080	70 560	5 188.2	4 900.0	4 410.0
9			5/6				78 400	5 764.7	5 444.4	4 900.0
10		1024-QAM	3/4	10		11 7600	88 200	6 485.3	6 125.0	5 512.5
11			5/6				98 000	7 205.9	6 805.6	6 125.0

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Table 28-105—HE-MCSs for non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	1 960	13 720	6 860	504.4	476.4	428.8
1		QPSK	1/2	2		27 440	13 720	1 008.8	952.8	857.5
2			3/4				20 580	1 513.2	1 429.2	1 286.3
3		16-QAM	1/2	4		54 880	27 440	2 017.6	1 905.6	1 715.0
4			3/4				41 160	3 026.5	2 858.3	2 572.5
5		64-QAM	2/3	6		82 320	54 880	4 035.3	3 811.1	3 430.0
6			3/4				61 740	4 539.7	4 287.5	3 858.8
7			5/6				68 600	5 044.1	4 763.9	4 287.5
8		256-QAM	3/4	8		109 760	82 320	6 052.9	5 716.7	5 145.0
9			5/6				91 466	6 725.4	6 351.8	5 716.6
10		1024-QAM	3/4	10		137 200	102 900	7 566.2	7 145.8	6 431.3
11			5/6				114 333	8 406.8	7 939.8	7 145.8

Table 28-106—HE-MCSs for non-OFDMA 160 MHz and 80+80 MHz, N_{SS} = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)		
								0.8 μs GI	1.6 μs GI	3.2 μs GI
0	N/A	BPSK	1/2	1	1 960	15 680	7 840	576.5	544.4	490.0
1		QPSK	1/2	2		31 360	15 680	1 152.9	1 088.9	980.0
2			3/4				23 520	1 729.4	1 633.3	1 470.0
3		16-QAM	1/2	4		62 720	31 360	2 305.9	2 177.8	1 960.0
4			3/4				47 040	3 458.8	3 266.7	2 940.0
5		64-QAM	2/3	6		94 080	62 720	4 611.8	4 355.6	3 920.0
6			3/4				70 560	5 188.2	4 900.0	4 410.0
7			5/6				78 400	5 764.7	5 444.4	4 900.0
8		256-QAM	3/4	8		125 440	94 080	6 917.6	6 533.3	5 880.0
9			5/6				104 533	7 686.3	7 259.2	6 533.3
10		1024-QAM	3/4	10		156 800	117 600	8 647.1	8 166.7	7 350.0
11			5/6				130 666	9 607.8	9 074.0	8 166.6

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Annex B

(normative)

Protocol Implementation Conformance Statement (PICS) proforma

B.4 PICS proforma—IEEE Std 802.11-<year>

Change B.4.3 as follows:

B.4.3 IUT configuration

Item	IUT configuration	References	Status	Support
	What is the configuration of the IUT?			
* CFOFDM	Orthogonal frequency division multiplexing (OFDM) PHY	—	O.2 CFHT5G:M CFTVHT:M CFHE:M	Yes ☐ No ☐
...				
*CFHT	High throughput (HT) PHY	9.4.2.56 (HT Capabilities element)	O.2 CFVHT:M CFHE:M	Yes ☐ No ☐
...				
*CFHT2G4	HE operation in the 2.4 GHz band	Clause 19	CFHT:O.6 CFHE:M	Yes ☐ No ☐ N/A ☐
*CFHT5G	HE operation in the 5 GHz band	Clause 19	CFHT:O.6 CFVHT:M CFHE:M	Yes ☐ No ☐ N/A ☐
..				
*CFVHT	Very High Throughput (VHT) features	9.4.2.158 (VHT Capabilities element)	O.2 CFHE:M	Yes ☐ No ☐
...				
*CFESM	Extended spectrum management	10.21.3 (Operation with operating classes)	O CFVHT OR CFTVHT:M	Yes ☐ No ☐
*CFHE	High efficiency (HE) operation	9.4.2.237 (HE Capabilities element)	O CFHE20:M CFHE80:M	Yes ☐ No ☐
*CFHE2G4	HE operation in 2.4 GHz band	Clause 28	O.8	Yes ☐ No ☐
*CFHE5G	HE operation in 5 GHz band	Clause 28	O.8	Yes ☐ No ☐
*CFHE20	HE operation with 20 MHz only	Clause 28	CFIndepSTA and CFHE:M	Yes ☐ No ☐

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B.4.3 IUT configuration *(continued)*

Item	IUT configuration	References	Status	Support
*CFHE80	HE operation with capability of 80 MHz or wider channel width	Clause 28	CFAP and CFHE and CFVHT:M CFIndepSTA and CFHE and CFVHT:M	Yes ☐ No ☐

B.4.4 MAC protocol

Change B.4.4.1 as follows:

B.4.4.1 MAC protocol capabilities

Item	Protocol capability	References	Status	Support
	Are the following MAC protocol capabilities supported?			
PC45	Dynamic fragmentation	10.3 (DCF), 10.5 (Fragmentation)		
PC45.1	Dynamic fragmentation level 1	27.3.2.2 (Level 1 dynamic fragmentation)	CFHE:O	Yes ☐ No ☐
PC45.2	Dynamic fragmentation level 2	27.3.2.3 (Level 2 dynamic fragmentation)	CFHE:O	Yes ☐ No ☐
PC6.2.3	Dynamic fragmentation level 3	27.3.2.4 (Level 3 dynamic fragmentation)	CFHE:O	Yes ☐ No ☐

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Change B.4.4.2 as follows:

B.4.4.2 MAC frames

Item	MAC frame	References	Status	Support
	Is transmission of the following MAC frames supported?	9 (Frame formats)		
FT42	Transmission of Operating Mode Notification frame and Operating Mode Notification element	9.6.23.4 (Operating Mode Notification frame format), 9.4.2.166 (Operating Mode Notification element), 11.42 (Notification of operating mode changes)	O	Yes ☐ No ☐ N/A ☐
FT43	Trigger frame	9 (Frame formats)	CFHE:M	Yes ☐ No ☐ N/A ☐
	Is reception of the following MAC frames supported?	9 (Frame formats)		
FR41	VHT NDP Announcement	9 (Frame formats)	VHTM4.2:M TVHTM4.2:M	Yes ☐ No ☐ N/A ☐
FR42	Beamforming Report Poll	9 (Frame formats)	VHTM4.2:O VHTM4.4:M TVHTM4.2:O TVHTM4.4:M	Yes ☐ No ☐ N/A ☐
FR43	Reception of Operating Mode Notification frame and Operating Mode Notification element	9.6.23.4 (Operating Mode Notification frame format), 9.4.2.166 (Operating Mode Notification element), 11.42 (Notification of operating mode changes)	CFVHT:M CFTVHT:M	Yes ☐ No ☐ N/A ☐
FR44	Trigger frame	9 (Frame formats)	CFHE:M	Yes ☐ No ☐ N/A ☐

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Change B.4.4.10 as follows:

B.4.10 QoS base functionality

Item	Protocol capability	References	Status	Support
...				
QB4	Block acknowledgments (block ack)			
...				
QB4.4	Multi-TID Block Ack	9.3.1.9.4 (Multi-TID BlockAck variant)	CFQoS:O CFHT OR CFT-VHT:M	Yes ☐ No ☐ N/A ☐
QB4.5	Multi-STA BlockAck	9.3.1.9.7 (Multi-STA BlockAck variant)	CFHE:M	Yes ☐ No ☐ N/A ☐
...				

Insert a new subclause B.4.27 as follows:

B.4.27 High efficiency (HE) features

B.4.27.1 HE MAC features

Item	Protocol capability	References	Status	Support
	Are the following MAC protocol features supported?			
HEM1	HE capabilities signaling			
HEM1.1	HE Capabilities element	9.4.2.237 (HE Capabilities element)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM1.2	Signaling of STA capabilities in Probe Request, (Re)Association Request frames	9.3.3.6 (Association Request frame format), 9.3.3.8 (Reassociation Request frame format), 9.3.3.10 (Probe Request frame format), 9.4.2.237 (HE Capabilities element)	(CFHE AND CFIndep-STA):M	Yes ☐ No ☐ N/A ☐

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B.4.27.1 HE MAC features *(continued)*

Item	Protocol capability	References	Status	Support
HEM1.3	Signaling of STA and BSS capabilities in Beacon, Probe Response, (Re)Association Response frames	9.3.3.3 (Beacon frame format), 9.3.3.7 (Association Response frame format), 9.3.3.9 (Reassociation Response frame format), 9.3.3.11 (Probe Response frame format), 9.4.2.237 (HE Capabilities element)	(CFVHT AND CFAP):M	Yes ☐ No ☐ N/A ☐
HEM2	Signaling of HE operation	9.4.2.238 (HE Operation element)	(CFHE AND CFAP):M	Yes ☐ No ☐ N/A ☐
HEM3	A-MPDU with multiple TIDs	27.10.4 (multi-TID A-MPDU and ack-enabled A-MPDU)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM4	HE variant HT Control			
HEM4.1	UL MU Response Scheduling	9.2.4.6.4.2 (UMRS Control)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM4.2	Operating Mode	9.2.4.6.4.3 (OM Control)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM4.3	HE Link Adaptation	9.2.4.6.4.4 (HLA Control)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM4.4	Buffer Status Report	9.2.4.6.4.5 (BSR Control)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM4.5	UL Power Headroom	9.2.4.6.4.6 (UPH Control)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM4.6	BQR Control	9.2.4.6.4.7 (BQR Control)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM4.7	CAS Control	9.2.4.6.4.8 (CAS Control)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM5	Trigger			
HEM5.1	Basic Trigger	9.3.1.23.1 (Basic Trigger variant)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM5.2	Beamforming Report Poll	9.3.1.23.2 (Beamforming Report Poll (BRP) variant)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM5.3	MU-BAR	9.3.1.23.3 (MU-BAR variant)	CFHE:O	Yes ☐ No ☐ N/A ☐

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B.4.27.1 HE MAC features *(continued)*

Item	Protocol capability	References	Status	Support
HEM5.4	MU-RTS transmission	9.3.1.23.4 (MU-RTS variant)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM5.5	MU-RTS reception	9.3.1.23.4 (MU-RTS variant)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM5.6	BSRP	9.3.1.23.5 (Buffer Status Report Poll (BSRP) variant)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM6	Transmit beamforming			
*HEM6.1	SU beamformer capable	9.4.2.237 (HE Capabilities element)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEM6.2	SU beamformee capable	9.4.2.237 (HE Capabilities element)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEM6.3	MU beamformer capable	9.4.2.237 (HE Capabilities element)	CFAP AND CFHEM6.1:O	Yes ☐ No ☐ N/A ☐
*HEM6.4	MU beamformee capable	9.4.2.237 (HE Capabilities element)	CFIndepSTA and VHTM7.2:O	Yes ☐ No ☐ N/A ☐
*HEM6.5	Transmission of HE NDP	27.6 (HE sounding protocol)	HEM6.1:M	Yes ☐ No ☐ N/A ☐
*HEM6.6	Reception of HE NDP	27.6 (HE sounding protocol)	HEM6.2:M	Yes ☐ No ☐ N/A ☐
*HEM6.7	Transmission of Trigger frame	27.6 (HE sounding protocol)	HEM6.1:O	Yes ☐ No ☐ N/A ☐
HEM6.8	Reception of Trigger frame	27.6 (HE sounding protocol)	HEM6.7:M	Yes ☐ No ☐ N/A ☐
HEM7	Sounding protocol			
HEM7.1	HE Sounding Protocol as SU beamformer	27.6 (HE sounding protocol)	HEM6.1:M	Yes ☐ No ☐ N/A ☐
HEM7.2	HE Sounding Protocol as SU beamformee	27.6 (HE sounding protocol)	HEM6.2:M	Yes ☐ No ☐ N/A ☐
HEM7.3	HE Sounding Protocol as MU beamformer	27.6 (HE sounding protocol)	HEM6.4:M	Yes ☐ No ☐ N/A ☐
HEM7.4	HE Sounding Protocol as MU beamformee	27.6 (HE sounding protocol)	HEM6.5:M	Yes ☐ No ☐ N/A ☐
HEM8	NAV update	27.2.4 (Updating two NAVs)		

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B.4.27.1 HE MAC features *(continued)*

Item	Protocol capability	References	Status	Support
HEM8.1	Update basic NAV	27.2.4 (Updating two NAVs)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEM8.2	Update IntraBSS NAV	27.2.4 (Updating two NAVs)	CFAP AND CFHE:O CFIndepSTA AND CFHE:M	Yes ☐ No ☐ N/A ☐
HEM9	OFDMA-based random access	27.5.5 (UL OFDMA-based random access (UORA))	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM10	TWT operation	27.7 (TWT operation)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM11	Quiet time period			
HEM11.1	Transmission of Quiet Time Period Request frame	27.16.4 (Quiet HE STAs in an HE BSS)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEM11.2	Reception of Quiet Time Period Response frame	27.16.4 (Quiet HE STAs in an HE BSS)	CFHE:M	Yes ☐ No ☐ N/A ☐

B.4.27.2 HE PHY features

Item	Protocol capability	References	Status	Support
	Are the following PHY protocol features supported?			
HEP1	PHY operating modes			
HEP1.1	Operation according to Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification) (Orthogonal frequency division multiplexing (OFDM) PHY specification), Clause 19 (High Throughput (HT) PHY specification) (High Throughput) and/or Clause 21 (Very High Throughput (VHT) PHY specification)	28.1.1 (Introduction to the HE PHY)	CFHE5G and (CFAP or CFHE80):M	Yes ☐ No ☐ N/A ☐
HEP1.2	Operation according Clause 19 (High Throughput (HT) PHY specification) (High Throughput) in 5GHz	28.1.1 (Introduction to the HE PHY)	CFHE5G and CFHE20: M	Yes ☐ No ☐ N/A ☐
HEP1.3	Operation according Clause 19 (High Throughput (HT) PHY specification) (High Throughput) in 2.4 GHz	28.1.1 (Introduction to the HE PHY)	CFHE2G4:M	Yes ☐ No ☐ N/A ☐
HEP2	HE PPDU format	28.1.4 (PPDU formats)		
*HEP2.1	HE SU PPDU	28.1.4 (PPDU formats)		Yes ☐ No ☐ N/A ☐

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B.4.27.2 HE PHY features *(continued)*

Item	Protocol capability	References	Status	Support
HEP2.2	HE ER SU PPDU	28.1.4 (PPDU formats)		Yes ☐ No ☐ N/A ☐
HEP2.3	HE MU PPDU	28.1.4 (PPDU formats)		Yes ☐ No ☐ N/A ☐
HEP2.4	HE TB PPDU	28.1.4 (PPDU formats)		Yes ☐ No ☐ N/A ☐
HEP3	BSS bandwidth			
*HEP3.1	20 MHz operation	27.16 (HE BSS operation)	CFHE: M	Yes ☐ No ☐ N/A ☐
*HEP3.2	40 MHz operation	27.16 (HE BSS operation)	CFHE80 and CFHE5G:M CFHE2G4:O	Yes ☐ No ☐ N/A ☐
*HEP3.3	80 MHz operation	27.16 (HE BSS operation)	CFHE80 and CFHE5G:M	Yes ☐ No ☐ N/A ☐
*HEP3.4	160 MHz operation	27.16 (HE BSS operation)	CFHE80 and CFHE5G:O HEP3.5:M	Yes ☐ No ☐ N/A ☐
*HEP3.5	80+80 MHz operation	27.16 (HE BSS operation)	CFHE80 and CFHE5G:O	Yes ☐ No ☐ N/A ☐
HEP4	PHY timing information			
HEP4.1	Values in 20 MHz channel	28.3.8 (Timing-related parameters)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEP4.2	Values in 40 MHz channel	28.3.8 (Timing-related parameters)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEP4.3	Values in 80 MHz channel	28.3.8 (Timing-related parameters)	CFHE:M	Yes ☐ No ☐ N/A ☐
HEP4.4	Values in 160 MHz channel	28.3.8 (Timing-related parameters)	HEP3.4:M	Yes ☐ No ☐ N/A ☐
HEP4.5	Values in 80+80 MHz channel	28.3.8 (Timing-related parameters)	HEP3.5:M	Yes ☐ No ☐ N/A ☐
HEP5	STBC	28.3.11.10 (Space-time block coding)	CFHE:O	Yes ☐ No ☐ N/A ☐
HEP6	Tone allocation			
*HEP6.1	26-tone RU mapping		CFHE:M	Yes ☐ No ☐ N/A ☐
*HEP6.2	52-tone RU mapping		CFHE:M	Yes ☐ No ☐ N/A ☐
*HEP6.3	106-tone RU mapping		CFHE:M	Yes ☐ No ☐ N/A ☐
*HEP6.4	242-tone RU mapping		CFHE80:M CFHE20:O	Yes ☐ No ☐ N/A ☐
*HEP6.5	484-tone RU mapping		CFHE80 and HEP3.2:M	Yes ☐ No ☐ N/A ☐

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B.4.27.2 HE PHY features *(continued)*

Item	Protocol capability	References	Status	Support
*HEP6.6	996-tone RU mapping		CFHE80 and HEP3.3:M CFHE80 and HEP3.4:M	Yes ☐ No ☐ N/A ☐
*HEP6.7	2x996-tone RU mapping		CFHE80 and HEP3.4:M	Yes ☐ No ☐ N/A ☐
HEP7	Coding			
HEP10.1	BCC with less than 4 spatial streams		(HEP6.1 or HEP6.2 or HEP6.3 or HEP6.4):M (HEP3.1 and HEP2.1):M	Yes ☐ No ☐ N/A ☐
HEP10.2	LDPC with more than 4 spatial streams		CFHE80:M CFHE20:O	Yes ☐ No ☐ N/A ☐
HEP10.3	LDPC with less or equal to 4 spatial streams		(HEP6.5 or HEP6.6 or HEP6.7):M ((HEP3.2 or HEP3.3 or HEP3.4 or HEP3.5) and HEP2.1):M (HEP6.1 or HEP6.2 or HEP6.3 or HEP6.4):O (HEP3.1 and HEP2.1):O CFHE20: O	Yes ☐ No ☐ N/A ☐
HEP11	STBC		CFHE: O	Yes ☐ No ☐ N/A ☐
HEP12	Coding and modulation schemes			
HEP12.1	For 26-, 52-, 106-, 242-, 484- and 996-tone mapping			
*HEP12.1.1	HE-MCS with Index 0-7 and $N_{SS} = 1$	28.5 (Parameters for HE-MCSs)	CFHE: M	Yes ☐ No ☐ N/A ☐
*HEP12.1.2	HE-MCS with Index 0-8 and $N_{SS} = 1$	28.5 (Parameters for HE-MCSs)	HEP12.1.1:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.3	HE-MCS with Index 0-9 and $N_{SS} = 1$	28.5 (Parameters for HE-MCSs)	HEP12.1.2:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.4	HE-MCS with Index 0-7 and $N_{SS} = 2$	28.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.5	HE-MCS with Index 0-8 and $N_{SS} = 2$	28.5 (Parameters for HE-MCSs)	HEP12.1.4:O	Yes ☐ No ☐ N/A ☐

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B.4.27.2 HE PHY features *(continued)*

Item	Protocol capability	References	Status	Support
*HEP12.1.6	HE-MCS with Index 0-9 and N_{SS} = 2	28.5 (Parameters for HE-MCSs)	HEP12.1.5:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.7	HE-MCS with Index 0-7 and N_{SS} = 3	28.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.8	HE-MCS with Index 0-8 and N_{SS} = 3	28.5 (Parameters for HE-MCSs)	HEP12.1.7:O	Yes ☐ No ☐ N/A ☐
HEP12.1.9	HE-MCS with Index 0-9 and N_{SS} = 3	28.5 (Parameters for HE-MCSs)	HEP12.1.8:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.10	HE-MCS with Index 0-7 and N_{SS} = 4	28.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.11	HE-MCS with Index 0-8 and N_{SS} = 4	28.5 (Parameters for HE-MCSs)	HEP12.1.10:O	Yes ☐ No ☐ N/A ☐
HEP12.1.12	HE-MCS with Index 0-9 and N_{SS} = 4	28.5 (Parameters for HE-MCSs)	HEP12.1.11:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.13	HE-MCS with Index 0-7 and N_{SS} = 5	28.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.14	HE-MCS with Index 0-8 and N_{SS} = 5	28.5 (Parameters for HE-MCSs)	HEP12.1.13:O	Yes ☐ No ☐ N/A ☐
HEP12.1.15	HE-MCS with Index 0-9 and N_{SS} = 5	28.5 (Parameters for HE-MCSs)	HEP12.1.14:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.16	HE-MCS with Index 0-7 and N_{SS} = 6	28.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.17	HE-MCS with Index 0-8 and N_{SS} = 6	28.5 (Parameters for HE-MCSs)	HEP12.1.16:O	Yes ☐ No ☐ N/A ☐
HEP12.1.18	HE-MCS with Index 0-9 and N_{SS} = 6	28.5 (Parameters for HE-MCSs)	HEP12.1.17:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.19	HE-MCS with Index 0-7 and N_{SS} = 7	28.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.20	HE-MCS with Index 0-8 and N_{SS} = 7	28.5 (Parameters for HE-MCSs)	HEP12.1.19:O	Yes ☐ No ☐ N/A ☐
HEP12.1.21	HE-MCS with Index 0-9 and N_{SS} = 7	28.5 (Parameters for HE-MCSs)	HEP12.1.20:O	Yes ☐ No ☐ N/A ☐
*HEP12.1.22	HE-MCS with Index 0-7 and N_{SS} = 8	28.5 (Parameters for HE-MCSs)	CFHE:O	Yes ☐ No ☐ N/A ☐

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B.4.27.2 HE PHY features *(continued)*

Item	Protocol capability	References	Status	Support
*HEP12.1.23	HE-MCS with Index 0-8 and N_{SS} = 8	28.5 (Parameters for HE-MCSs)	HEP12.1.22:O	Yes ☐ No ☐ N/A ☐
HEP12.1.24	HE-MCS with Index 0-9 and N_{SS} = 8	28.5 (Parameters for HE-MCSs)	HEP12.1.23:O	Yes ☐ No ☐ N/A ☐
HEP12.2	For 242-, 484- and 996-tone plan			
*HEP12.2.1	HE-MCS with Index 0-10 and N_{SS} = 1	28.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP12.2.2	HE-MCS with Index 0-11 and N_{SS} = 1	28.5 (Parameters for HE-MCSs)	HEP12.2.1:O	Yes ☐ No ☐ N/A ☐
*HEP12.2.3	HE-MCS with Index 0-10 and N_{SS} = 2	28.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP12.2.4	HE-MCS with Index 0-11 and N_{SS} = 2	28.5 (Parameters for HE-MCSs)	HEP12.2.3:O	Yes ☐ No ☐ N/A ☐
*HEP12.2.5	HE-MCS with Index 0-10 and N_{SS} = 3	28.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP12.2.6	HE-MCS with Index 0-11 and N_{SS} = 3	28.5 (Parameters for HE-MCSs)	HEP12.2.5:O	Yes ☐ No ☐ N/A ☐
*HEP12.2.7	HE-MCS with Index 0-10 and N_{SS} = 4	28.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP12.2.8	HE-MCS with Index 0-11 and N_{SS} = 4	28.5 (Parameters for HE-MCSs)	HEP12.2.7:O	Yes ☐ No ☐ N/A ☐
*HEP12.2.9	HE-MCS with Index 0-10 and N_{SS} = 5	28.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP12.2.10	HE-MCS with Index 0-11 and N_{SS} = 5	28.5 (Parameters for HE-MCSs)	HEP12.2.9:O	Yes ☐ No ☐ N/A ☐
*HEP12.2.11	HE-MCS with Index 0-10 and N_{SS} = 6	28.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP12.2.12	HE-MCS with Index 0-11 and N_{SS} = 6	28.5 (Parameters for HE-MCSs)	HEP12.2.11:O	Yes ☐ No ☐ N/A ☐
*HEP12.2.13	HE-MCS with Index 0-10 and N_{SS} = 7	28.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP12.2.14	HE-MCS with Index 0-11 and N_{SS} = 7	28.5 (Parameters for HE-MCSs)	HEP12.2.13:O	Yes ☐ No ☐ N/A ☐

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B.4.27.2 HE PHY features *(continued)*

Item	Protocol capability	References	Status	Support
*HEP12.2.15	HE-MCS with Index 0-10 and $N_{SS} = 8$	28.5 (Parameters for HE-MCSs)	CFHE80: O	Yes ☐ No ☐ N/A ☐
HEP12.2.16	HE-MCS with Index 0-11 and $N_{SS} = 8$	28.5 (Parameters for HE-MCSs)	HEP12.2.15:O	Yes ☐ No ☐ N/A ☐

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Annex C

(normative)

ASN.1 encoding of the MAC and PHY MIB

C.3 MIB Detail

Change the dot11smt object as follows:

```
dot11smt OBJECT IDENTIFIER ::= { ieee802dot11 1 }
…
-- dot11STACivicLocationConfigTable::= { dot11smt 37 }
-- dot11HEStationConfigTable::= { dot11smt 42 }
-- dot11PPEThresholdsMappingsTable::= { dot11smt 43 }
…
```

Change Dot11StationConfigEntry as follows:

```
Dot11StationConfigEntry ::= SEQUENCE
    {
        …,
        dot11FutureChannelGuidanceActivated                    TruthValue,
        dot11HEOptionImplemented                               TruthValue,
        dot11OBSSNarrowBWRUinULOFDMATolerated                  TruthValue
    }
…
```

Insert the following after the dot11FutureChannelGuidanceActivated OBJECT-TYPE element in the Dot11StationConfig TABLE:

```
dot11HEOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
    "This is a capability variable.
    Its value is determined by device capabilities.

    This attribute indicates whether the entity is HE Capable."
::= { dot11StationConfigEntry 181}

dot11OBSSNarrowBWRUinULOFDMATolerated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
    "This is a capability variable.
    Its value is determined by device capabilities.

    This attribute indicates whether the AP STA is able to tolerate 26-tone RU UL
        OFDMA transmissions using HE TB PPDU from OBSS (not falsely classify the
        26-tone RU UL OFDMA transmissions as radar pulses)."
::= { dot11StationConfigEntry 182 }
```

Insert the following after the dot11S1GStationConfig TABLE:

```
-- ****************************************************************
-- * dot11HEStationConfig TABLE
-- ****************************************************************
```

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```
dot11HEStationConfigTable OBJECT-TYPE
   SYNTAX SEQUENCE OF Dot11HEStationConfigEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "Station Configuration attributes. In tabular form to allow for multiple
      instances on an agent."
   ::= { dot11smt 42( }

dot11HEStationConfigEntry OBJECT-TYPE
   SYNTAX Dot11HEStationConfigEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "An entry (conceptual row) in the dot11HEStationConfig Table.

      ifIndex - Each IEEE 802.11 interface is represented by an ifEntry. Inter-
      face tables in this MIB module are indexed by ifIndex."
   INDEX { ifIndex }
   ::= { dot11HEStationConfigTable 1 }

Dot11HEStationConfigEntry ::=
   SEQUENCE {
      dot11HEULMUResponseSchedulingOptionImplemented        TruthValue,
      dot11ULMUMIMOOptionImplemented                        TruthValue,
      dot11OFDMARandomAccessOptionImlemented                TruthValue,
      dot11HEControlFieldOptionImplemented                  TruthValue,
      dot11OMIOptionImplemented                             TruthValue,
      dot11HEMCSFeedbackOptionImplemented                   TruthValue,
      dot11HEDynamicFragmentationLevel                      INTEGER,
      dot11AMPDUwithMultipleTIDOptionImplemented            TruthValue,
      dot11MPDUAskedforAckInMultiTIDAMPDU                   TruthValue,
      dot11TXOPDurationRTSThreshold                         Unsigned32,
      dot11PPEThresholdsRequired                            TruthValue,
      dot11IntraPPDUPowerSaveOptionActivated                TruthValue,
      dot11AMSDUFragmentationOptionImplemented              TruthValue,
      dot11BSSColorCollisionAPPeriod                        Unsigned32,
      dot11BSSColorCollisionSTAPeriod                       Unsigned32,
      dot11AutonomousBSSColorCollisionReportingImplemented  TruthValue,
      dot11HESRPOptionImplemented                           TruthValue,
      dot11HEBSRControlImplemented                          TruthValue,
      dot11HEUPHControlActivated                            TruthValue,
      dot11HEBQRControlImplemented                          TruthValue,
      dot11HECASControlImplemented                          TruthValue,
      dot11PartialBSSColorImplemented                       TruthValue
   }

dot11HEULMUResponseSchedulingOptionImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.

      This attribute, when true, indicates that the station implementation is
      capable of receiving frames with a UMRS Control field. The capability is
      disabled otherwise."
   DEFVAL { false }
   ::= { dot11HEStationConfigEntry 1}

dot11ULMUMIMOOptionImplemented OBJECT-TYPE
   SYNTAX TruthValue
```


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```
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute, when true, indicates that the station implementation is
       capable of a full bandwidth UL MU-MIMO transmission. The capability is
       disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 2}

dot11OFDMARandomAccessOptionImlemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute, when true, indicates that the station implementation is
       capable of an OFDMA random access operation. The capability is disabled
       otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 3}

dot11HEControlFieldOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute, when true, indicates that the station implementation is
       capable of receiving the HE variant HT Control field. The capability is
       disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 4}

dot11OMIOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute, when true, indicates that the station implementation is
       capable of receiving frames with an OM Control subfield. The capability is
       disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 5}

dot11HEMCSFeedbackOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute indicates the MCS feed back capability supported by the
       station implementation."
```

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```
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 6}

dot11HEDynamicFragmentationLevel OBJECT-TYPE
    SYNTAX INTEGER{ HEDynamicFragmentationLevel1(1), HEDynamicFragmentationLev-
       el2(2), HEDynamicFragmentationLevel3(3)}
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       HEDynamicFragmentationLevel1 indicates that the STA allows transmission or
       reception of one fragment at a time and does not need block ack agreement
       negotiation.

       HEDynamicFragmentationLevel2 indicates that the STA allows transmission or
       reception of multiple fragments at a time, up to one per MSDU or A-MSDU,
       needs block ack agreement negotiation, and uses HT-immediate blockack sig-
       nalling.

       HEDynamicFragmentationLevel3 indicates that the STA allows transmission or
       reception of multiple fragments at a time, up to four per MSDU or A-MSDU,
       needs block ack agreement negotiation, and uses block ack signaling that
       is specific to dynamic fragmentation level 3"
    ::= { dot11HEStationConfigEntry 7}

dot11AMPDUwithMultipleTIDOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute, when true, indicates that the station implementation is
       capable of generating an A-MPDU that contains QoS Data frames with two or
       more different TID values. The capability is disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 8}

dot11MPDUAskedforAckInMultiTIDAMPDU OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.

       This attribute, when true, indicates that the station implementation is
       capable of receiving a multi-TID A-MPDU that can solicit either Ack or
       BlockAck, or both. The capability is disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 9}

dot11TXOPDurationRTSThreshold OBJECT-TYPE
    SYNTAX Unsigned32 (0..1023)
    UNITS "32 microseconds"
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by an external management entity or by the MAC of a non-AP
       HE STA upon receiving an HE Operation element from the HE AP with which it
```


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```
        is associated.
        Changes take effect as soon as practical in the implementation.

        This attribute indicates the duration of the transmission or TXOP above
        which an RTS/CTS handshake is performed. Value zero means the RTS should
        be always used for TXOP transmission. Value 1023 means this feature is
        disabled"
    DEFVAL { 1023 }
    ::= { dot11HEStationConfigEntry 10}

dot11PPEThresholdsRequired OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        This attribute, when true, indicates that Post-FEC Padding and Packet
        Extension Thresholds exist and are provided in dot11PPEThresholdsTable."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 11}

dot11IntraPPDUPowerSaveOptionActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the station implementation is
        capable of Intra PPDU Power Save operation. The capability is disabled
        otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 12}

dot11AMSDUFragmentationOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable. Its value is determined by device
         capabilities.

         This attribute, when true, indicates that the STA implementation is
         capable of receiving dynamic fragments of A-MSDUs. The capability is
         disabled otherwise."
    DEFVAL { false }
::= { dot11HEStationConfigEntry 13}

dot11BSSColorCollisionAPPeriod OBJECT-TYPE
    SYNTAX Unsigned32 (50..255)
    UNITS "seconds"
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The attribute indicates the duration for which an HE AP shall wait before
        disabling BSS color. The minimum value of this variable is 50."
    DEFVAL { 50 }
    ::= { dot11HEStationConfigEntry 14}

dot11BSSColorCollisionSTAPeriod OBJECT-TYPE
    SYNTAX Unsigned32 (5..10)
    UNITS "seconds"
```

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```
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The attribute indicates the interval between successive BSS color
         collision reports. The maximum value of this variable is 10."
    DEFVAL { 5 }
    ::= { dot11HEStationConfigEntry 15}

dot11AutonomousBSSColorCollisionReportingImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        This attribute, when true, indicates that autonomously detecting and
        reporting of BSS color collision is implemented."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 16}

dot11HESRPOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable. Its value is determined by device
        capabilities.

        This attribute, when true, indicates that the STA implementation is
        capable of transmitting Spatial Reuse Parameters in HE PPDUs. The
        capability is disabled otherwise."
DEFVAL { false }
::= { dot11HEStationConfigEntry 17}

dot11HEBSRControlImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the station implementation is
        capable of receiving frames with a BSR Control subfield. The capability is
        disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 18}

dot11HEUPHControlActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a control variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the station implementation is
        capable of receiving frames with an UPH Control subfield. The capability
        is disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 19}

dot11HEBQRControlImplemented OBJECT-TYPE
    SYNTAX TruthValue
```


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```
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the station implementation is
        capable of receiving frames with a BQR Control subfield. The capability is
        disabled otherwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 20}

dot11HECASControlImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        This attribute, when true, indicates that the station implementation is
        capable of receiving frames with a CAS Control subfield. The capability is
        disabled otherwise(."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 21}

dot11PartialBSSColorImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        This attribute, when true, indicates that the partial BSS color (see
        27.16.3 (AID assignment)) is implemented. The capability is disabled oth-
        erwise."
    DEFVAL { false }
    ::= { dot11HEStationConfigEntry 22}


-- ********************************************************************
-- * End of dot11HEStationConfigTable TABLE
-- ********************************************************************

-- ********************************************************************
-- * dot11PPEThresholdsMappings TABLE
-- ********************************************************************
dot11PPEThresholdsMappingsTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot11PPEThresholdsMappingsEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "Conceptual table for PPE Thresholds Mappings. The MIB supports the
         ability to share separate PPE Thresholds for each NSS/RU pair. The
         Thresholds Mappings Table contains one entry for each NSS/RU pair
         and contains two fields for each entry: PPET8 and PPET16. The PPE
         Thresholds mappings are logically WRITE-ONLY. Attempts to read the
         entries in this table return unsuccessful status and values of null or 0.
         The default value for all PPET8 fields is NONE."
    REFERENCE "IEEE Std 802.11-<year>, 27.12 (HE PPDU post FEC padding and packet
        extension)"
::= { dot11smt 43}

dot11PPEThresholdsMappingsEntry OBJECT-TYPE
```

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```
    SYNTAX Dot11PPEThresholdsMappingsEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "An Entry (conceptual row) in the PPE Thresholds Mappings Table.
         ifIndex - Each IEEE Std 802.11 interface is represented by an ifEntry.
         Interface tables in this MIB module are indexed by ifIndex."
    INDEX { ifIndex, dot11PPEThresholdsMappingIndex }
::= { dot11PPEThresholdsMappingsTable 1 }

Dot11PPEThresholdsMappingsEntry ::= SEQUENCE {
    dot11PPEThresholdsMappingIndex                  Unsigned32,
    dot11PPEThresholdsMappingNSS                    Integer,
    dot11PPEThresholdsMappingRUIndex                Integer,
    dot11PPEThresholdsMappingPPET8                  Integer,
    dot11PPEThresholdsMappingPPET16                 Integer,
    dot11PPEThresholdsMappingStatus                 RowStatus}

dot11PPEThresholdsMappingIndex OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
    "The auxiliary variable used to identify instances of the columnar objects
     in the PPE Thresholds Mappings Table."
::= { dot11PPEThresholdsMappingsEntry 1 }

dot11PPEThresholdsMappingNSS OBJECT-TYPE
    SYNTAX Integer
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The NSS value portion of the NSS/RU pair for which the values from this
         Thresholds mapping entry are to be used."
::= { dot11PPEThresholdsMappingsEntry 2 }

dot11PPEThresholdsMappingRUIndex OBJECT-TYPE
    SYNTAX Integer
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The index of the RU value portion of the NSS/RU pair for which the values
         from this Thresholds mapping entry are to be used. The index values
         map to an RU as follows: RU Index of 0 is 996 tones, 1 is 448 tones,
         2 is 996 tones, 3 is 2x996 tones."
::= { dot11PPEThresholdsMappingsEntry 3 }

dot11PPEThresholdsMappingPPET8 OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "An index that determines a constellation value at or above which a
         Post FEC Padding and Packet Extension value of at least
         8 microseconds is required for the given NSS/RU pair
         corresponding to the row of the entry. The index values are mapped
         as follows: 0 is BPSK, 1 is QPSK, 2 is 16-QAM, 3 is 64-QAM,
         4 is 256-QAM, 5 is 1024-QAM, 6 is reserved, 7 is the special
         value of NONE."
::= { dot11PPEThresholdsMappingsEntry 4 }

dot11PPEThresholdsMappingPPET16 OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
```


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```
    STATUS current
    DESCRIPTION
        "An index that determines a constellation value at or above which a
         Post FEC Padding and Packet Extension value of 16 microseconds
         is required for the given NSS/RU pair corresponding to the row of the
         entry. The index values are mapped as follows: 0 is BPSK, 1 is QPSK,
         2 is 16-QAM, 3 is 64-QAM, 4 is 256-QAM, 5 is 1024-QAM, 6 is reserved,
         7 is the special value of NONE."
::= { dot11PPEThresholdsMappingsEntry 5 }

dot11PPEThresholdsMappingStatus OBJECT-TYPE
    SYNTAX RowStatus
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The status column used for creating, modifying, and deleting instances
         of the columnar objects in the PPE Thresholds mapping Table."
    DEFVAL { active }
::= { dot11PPEThresholdsMappingsEntry 6 }

-- ************************************************************************
-- * End of dot11PPEThresholdsMappings TABLE
-- ************************************************************************
```

Change dot11PHYType as follows:

```
dot11PHYType OBJECT-TYPE
    SYNTAX INTEGER {
        fhss(1),
        dsss(2),
        irbaseband(3),
        ofdm(4),
        hrdsss(5),
        erp(6),
        ht(7)
        dmg(8),
        vht(9),
        tvht(10),
        s1g(11),
        cdmg(12),
        CMMG(13),
        he (<ANA>) }
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a status variable.
        It is written by the PHY.

        This is an 8-bit integer value that identifies the PHY type supported by
        the attached PLCP and PMD. Currently defined values and their correspond-
        ing PHY types are:

        FHSS 2.4 GHz = 01, DSSS 2.4 GHz = 02, IR Baseband = 03,
        OFDM = 04, HRDSSS = 05, ERP = 06, HT = 07, DMG = 08, VHT = 09, TVHT = 10,
        HE = 11, CDMG = 12, CMMG = 13, HE = <ANA>"
    ::= { dot11PhyOperationEntry 1 }

-- ************************************************************************
-- * dot11 Phy HE TABLE
-- ************************************************************************
dot11PhyHETable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot11PhyHEEntry
    MAX-ACCESS not-accessible
    STATUS current
```

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```
    DESCRIPTION
        "Entry of attributes for dot11PhyHETable. Implemented as a table indexed
         on ifIndex to allow for multiple instances on an Agent."
::= { dot11phy 31 }

dot11PhyHEEntry OBJECT-TYPE
    SYNTAX Dot11PhyHEEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "An entry in the dot11PhyHEEntry Table. ifIndex - Each IEEE Std 802.11
         interface is represented by an ifEntry. Interface tables in this MIB
         module are indexed by ifIndex."
    INDEX {ifIndex}
::= { dot11PhyHETable 1 }

Dot11PhyHEEntry ::=
    SEQUENCE {
        dot11HECCAIndicationMode                                INTEGER,
        dot11HEDualBandImplemented                              TruthValue,
        dot11HECurrentChannelWidthSet                           BITS,
        dot11HEPuncturedPreambleTxImplemented                   BITS,
        dot11HEPuncturedPreambleTxActivated                     BITS,
        dot11HEPuncturedPreambleRxImplemented                   BITS,
        dot11HEPuncturedPreambleRxActivated                     BITS,
        dot11HEDeviceClass                                      INTEGER,
        dot11HELPDCCodingInPayloadImplemented                   TruthValue,
        dot11HELPDCCodingInPayloadActivated                     TruthValue,
        dot11HESUPPDUwith1xHELTFand0point8GIImplemented         TruthValue,
        dot11HESUPPDUwith1xHELTFand0point8GIActivated           TruthValue,
        dot11HESUPPDUwith4xHELTFand0point8GIImplemented         TruthValue,
        dot11HESUPPDUwith4xHELTFand0point8GIActivated           TruthValue,
        dot11HENDPwith4xHELTFand3point2GIImplemented            TruthValue,
        dot11HENDPwith4xHELTFand3point2GIActivated              TruthValue,
        dot11HESTBCTxLessThanOrEqualTo80Implemented             TruthValue,
        dot11HESTBCTxLessThanOrEqualTo80Activated               TruthValue,
        dot11HESTBCRxLessThanOrEqualTo80Implemented             TruthValue,
        dot11HESTBCRxLessThanOrEqualTo80Activated               TruthValue,
        dot11HESTBCTxGreaterThan80Implemented                   TruthValue,
        dot11HESTBCTxGreaterThan80Activated                     TruthValue,
        dot11HESTBCRxGreaterThan80Implemented                   TruthValue,
        dot11HESTBCRxGreaterThan80Activated                     TruthValue,
        dot11HEDopplerImplemented                               TruthValue,
        dot11HEDopplerActivated                                 TruthValue,
        dot11HEDCMImplemented                                   BITS,
        dot11HEDCMActivated                                     BITS,
        dot11HEFullBWULMUMIMOImplemented                        TruthValue,
        dot11HEFullBWULMUMIMOActivated                          TruthValue,
        dot11HEPartialBWULMUMIMOImplemented                     TruthValue,
        dot11HEPartialBWULMUMIMOActivated                       TruthValue,
        dot11HEPartialBWDLMUMIMOImplemented                     TruthValue,
        dot11HEPartialBWDLMUMIMOActivated                       TruthValue,
        dot11HEULMUPayloadImplemented                           TruthValue,
        dot11HEULMUPayloadActivated                             TruthValue,
        dot11HEPowerBoostFactorImplemented                      TruthValue,
        dot11HEPowerBoostFactorActivated                        TruthValue,
        dot11HEPartialBWERSUPayloadImplemented                  TruthValue,
        dot11HEPartialBWERSUPayloadActivated                    TruthValue
    }

dot11HECCAIndicationMode OBJECT-TYPE
    SYNTAX INTEGER {
        singleelement (0),
        per20bitmap (1),
```


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```
        per20bitmapsifs (2) }
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable.
         It is written by an external management entity.
         Changes take effect as soon as practical in the implementation.
         The current CCA method in operation for an HE PHY. Valid values are:
         When the channel-list of a PHY-CCA.indication primitive contains only
         single element, it is set to 0 (singleelement).
         When the channel-list of a PHY-CCA.indication primitive contains a
         per20MHzbitmap and the channel-list is used for the preamble puncturing
         transmission, it is set to 1 (per20bitmap).
         When the channel-list of a PHY-CCA.indication primitive contains a
         per20MHz bitmap measured during the SIFS time and the channel-list is
         used for the HE TB PPDU transmission and BQR operation, it is
         set 2 (per20bitmapsifs)."
::= { dot11PhyHEEntry 1 }

dot11HEDualBandImplemented OBJECT-TYPE
SYNTAX BITS
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
::= { dot11PhyHEEntry 2 }

dot11HECurrentChannelWidthSet OBJECT-TYPE
SYNTAX BITS
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a status variable."
::= { dot11PhyHEEntry 3 }

dot11HEPuncturedPreambleTxImplemented OBJECT-TYPE
SYNTAX BITS
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
::= { dot11PhyHEEntry 4 }

dot11HEPuncturedPreambleTxActivated OBJECT-TYPE
SYNTAX BITS
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
::= { dot11PhyHEEntry 5 }

dot11HEPuncturedPreambleRxImplemented OBJECT-TYPE
SYNTAX BITS
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
::= { dot11PhyHEEntry 6 }
```

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```
dot11HEPuncturedPreambleRxActivated OBJECT-TYPE
SYNTAX BITS
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
::= { dot11PhyHEEntry 7 }

dot11HEDeviceClass OBJECT-TYPE
SYNTAX INTEGER
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities.
This attribute, when true, indicates that the STA implementation is
capable of TBD."
::= { dot11PhyHEEntry 8 }

dot11HELPDCCodingInPayloadImplemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 9 }

dot11HELPDCCodingInPayloadActivated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 10 }

dot11HESUPPDUwith1xHELTFand0point8GIlmplemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 11 }

dot11HESUPPDUwith1xHELTFand0point8GIActivated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 12 }

dot11HESUPPDUwith4xHELTFand0point8GIlmplemented OBJECT-TYPE
```


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```
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 13 }

dot11HESUPPDUwith4xHELTFand0point8GIActivated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 14 }

dot11HENDPwith4xHELTFand3point2GIImplemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 15 }

dot11HENDPwith4xHELTFand3point2GIActivated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 16 }

dot11HESTBCTxLessThanOrEqualTo80Implemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 17 }

dot11HESTBCTxLessThanOrEqualTo80Activated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 18 }

dot11HESTBCRxLessThanOrEqualTo80Implemented OBJECT-TYPE
SYNTAX TruthValue
```

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```
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 19 }

dot11HESTBCRxLessThanOrEqualTo80Activated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 20 }

dot11HESTBCTxGreaterThan80Implemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 21 }

dot11HESTBCTxGreaterThan80Activated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 22 }

dot11HESTBCRxGreaterThan80Implemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 23 }

dot11HESTBCRxGreaterThan80Activated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 24 }

dot11HEDopplerImplemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
```


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```
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 25 }

dot11HEDopplerActivated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 26 }

dot11HEDCMImplemented OBJECT-TYPE
SYNTAX BITS
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
::= { dot11PhyHEEntry 27 }

dot11HEDCMActivated OBJECT-TYPE
SYNTAX BITS
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
::= { dot11PhyHEEntry 28 }

dot11HEFullBWULMUMIMOImplemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 29 }

dot11HEFullBWULMUMIMOActivated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 30 }

dot11HEPartialBWULMUMIMOImplemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
```

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```
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 31 }

dot11HEPartialBWULMUMIMOActivated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 32 }

dot11HEPartialBWDLMUMIMOImplemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 33 }

dot11HEPartialBWDLMUMIMOActivated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 34 }

dot11HEULMUPayloadImplemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 35 }

dot11HEULMUPayloadActivated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 36 }

dot11HEPowerBoostFactorImplemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
```


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```
DEFVAL { false }
::= { dot11PhyHEEntry 37 }

dot11HEPowerBoostFactorActivated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 38 }

dot11HEPartialBWERSUPayloadImplemented OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"This is a capability variable.
Its value is determined by device capabilities."
DEFVAL { false }
::= { dot11PhyHEEntry 39 }

dot11HEPartialBWERSUPayloadActivated OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"This is a control variable.
It is written by an external management entity.
Changes take effect as soon as practical in the implementation."
DEFVAL { false }
::= { dot11PhyHEEntry 40 }

-- ************************************************************************
-- * End of dot11 Phy HE TABLE
-- ************************************************************************


-- ************************************************************************
-- * dot11 HE Transmit Beamforming Config TABLE
-- ************************************************************************

dot11HETransmitBeamformingConfigTable OBJECT-TYPE
   SYNTAX SEQUENCE OF Dot11HETransmitBeamformingConfigEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "Entry of attributes for dot11HETransmitBeamformingConfigTable. Imple-
      mented as a table indexed on ifIndex to allow for multiple instances on an
      Agent."
   ::= { dot11phy <ANA> }

dot11HETransmitBeamformingConfigEntry OBJECT-TYPE
   SYNTAX Dot11HETransmitBeamformingConfigEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "An entry in the dot11HETransmitBeamformingConfig Table.
      ifIndex - Each IEEE 802.11 interface is represented by an ifEntry. Inter-
      face tables in this MIB module are indexed by ifIndex."
   INDEX {ifIndex}
   ::= { dot11HETransmitBeamformingConfigTable 1 }
```

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```
Dot11HETransmitBeamformingConfigEntry ::=
   SEQUENCE {
      dot11HESUBeamformerOptionImplemented                  TruthValue,
      dot11HESUBeamformeeOptionImplemented                  TruthValue,
      dot11HEMUBeamformerOptionImplemented                  TruthValue,
      dot11HEBeamformeeSTSSupportLessThanOrEqualTo80        Unsigned32,
      dot11HEBeamformeeSTSSupportGreaterThan80              Unsigned32,
      dot11HENumberSoundingDimensionsLessThanOrEqualTo80    Unsigned32,
      dot11HENumberSoundingDimensionsGreaterThan80          Unsigned32,
      dot11HENG16SUFeedbackSupport                          TruthValue,
      dot11HENG16MUFeedbackSupport                          TruthValue,
      dot11HECodebookSizePhi4Psi2SUFeedbackSupport          TruthValue,
      dot11HECodebookSizePhi7Psi5MUFeedbackSupport          TruthValue,
      dot11HETriggeredSUBeamformingFeedbackImplemented      TruthValue,
      dot11HETriggeredSUBeamformingFeedbackActivated        TruthValue,
      dot11HETriggeredMUBeamformingFeedbackImplemented      TruthValue,
      dot11HETriggeredMUBeamformingFeedbackActivated        TruthValue,
      dot11HETriggeredCQIFeedbackSupportImplemented         TruthValue,
      dot11HETriggeredCQIFeedbackSupportActivated           TruthValue
   }

dot11HESUBeamformerOptionImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities."
   DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 1}

dot11HESUBeamformeeOptionImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities."
   DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 2 }

dot11HEMUBeamformerOptionImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities."
   DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 3 }

dot11HEBeamformeeSTSSupportLessThanOrEqualTo80 OBJECT-TYPE
   SYNTAX Unsigned32
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities."
::= { dot11HETransmitBeamformingConfigEntry 4 }

dot11HEBeamformeeSTSSupportGreaterThan80 OBJECT-TYPE
   SYNTAX Unsigned32
   MAX-ACCESS read-only
```


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```
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities."
::= { dot11HETransmitBeamformingConfigEntry 5 }

dot11HENumberSoundingDimensionsLessThanOrEqualTo80 OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities."
::= { dot11HETransmitBeamformingConfigEntry 6 }

dot11HENumberSoundingDimensionsGreaterThan80 OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities."
::= { dot11HETransmitBeamformingConfigEntry 7 }

dot11HENG16SUFeedbackSupport OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
    "This is a capability variable.
    Its value is determined by device capabilities."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 8 }

dot11HENG16MUFeedbackSupport OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 9 }

dot11HECodebookSizePhi4Psi2SUFeedbackSupport OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 10 }

dot11HECodebookSizePhi7Psi5MUFeedbackSupport OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities."
    DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 11 }
```

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```
dot11HETriggeredSUBeamformingFeedbackImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities."
   DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 12 }

dot11HETriggeredSUBeamformingFeedbackActivated OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-write
   STATUS current
   DESCRIPTION
      "This is a control variable.
      It is written by an external management entity.
      Changes take effect as soon as practical in the implementation."
   DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 13 }

dot11HETriggeredMUBeamformingFeedbackImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities."
   DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 14 }

dot11HETriggeredMUBeamformingFeedbackActivated OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-write
   STATUS current
   DESCRIPTION
      "This is a control variable.
      It is written by an external management entity.
      Changes take effect as soon as practical in the implementation."
   DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 15 }

dot11HETriggeredCQIFeedbackSupportImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities."
   DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 16 }

dot11HETriggeredCQIFeedbackSupportActivated OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-write
   STATUS current
   DESCRIPTION
      "This is a control variable.
      It is written by an external management entity.
      Changes take effect as soon as practical in the implementation."
   DEFVAL { false }
::= { dot11HETransmitBeamformingConfigEntry 17 }

-- ****************************************************************
```


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```
-- * End of dot11 HE Transmit Beamforming Config TABLE
-- ************************************************************************
```

Insert the following after the dot11FineTimingMeasurement OBJECT-GROUP:

```
dot11SMTbase14 OBJECT-GROUP
    OBJECTS {
        dot11HEOptionImplemented
    }
    STATUS current
    DESCRIPTION
        "The SMTbase14 object class provides the necessary support at the STA to
        manage the processes in the STA such that the STA may work cooperatively
        as a part of an IEEE 802.11 network."
    ::= { dot11Groups <ANA> }
```

Change the MANDATORY-GROUPS element in the dot11Compliance MODULE-COMPLIANCE as follows:

```
dot11Compliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "The compliance statement for SNMPv2 entities that implement the IEEE
        802.11 MIB."
    MODULE -- this module
    MANDATORY-GROUPS {
        ~~dot11SMTbase13~~ dot11SMTbase14,
        dot11MACbase4,
        dot11CountersGroup4,
        dot11SmtAuthenticationAlgorithms,
        dot11ResourceTypeID,
        dot11PhyOperationComplianceGroup2 }
```

Insert the following compliance objects after the dot11S1GComplianceGroup object:

```
dot11HEComplianceGroup OBJECT-GROUP
    OBJECTS {
        dot11HEULMUResponseSchedulingOptionImplemented,
        dot11ULMUMIMOOptionImplemented,
        dot11OFDMARandomAccessOptionImlemented,
        dot11HEControlFieldOptionImplemented,
        dot11OMIOptionImplemented,
        dot11HEMCSFeedbackOptionImplemented,
        dot11HEDynamicFragmentationImplemented,
        dot11AMPDUwithMultipleTIDOptionImplemented,
        dot11MPDUAskedforAckInMultiTIDAMPDU,
        dot11DurationRTSThreshold,
        dot11PPEThresholdsRequired,
        dot11IntraPPDUPowerSaveOptionActivated,
        dot11PartialBSSColorImplemented}
    STATUS current
    DESCRIPTION
        "Attributes that configure the HE Group for IEEE 802.11."
::= { dot11Groups 100 }

dot11HETransmitBeamformingGroup OBJECT-GROUP
    OBJECTS {
        dot11HESUBeamformerOptionImplemented,
        dot11HESUBeamformeeOptionImplemented,
        dot11HEMUBeamformerOptionImplemented,
        dot11HEBeamformeeSTSSupportLessThanOrEqualTo80,
        dot11HEBeamformeeSTSSupportGreaterThan80,
```

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```
        dot11HENumberSoundingDimensionsLessThanOrEqualTo80,
        dot11HENumberSoundingDimensionsGreaterThan80,
        dot11HENG16SUFeedbackSupport,
        dot11HENG16MUFeedbackSupport,
        dot11HECodebookSizePhi4Psi2SUFeedbackSupport,
        dot11HECodebookSizePhi7Psi5MUFeedbackSupport,
        dot11HETriggeredSUBeamformingFeedbackImplemented,
        dot11HETriggeredMUBeamformingFeedbackImplemented,
        dot11HETriggeredCQIFeedbackSupportImplemented }
    STATUS current
    DESCRIPTION
        "Attributes that configure HE transmit beamforming for IEEE 802.11."
    ::= { dot11Groups <ANA> }

dot11PhyHEComplianceGroup OBJECT-GROUP
    OBJECTS {
        dot11HEDualBandImplemented,
        dot11HECurrentChannelWidthSet,
        dot11HEPuncturedPreambleTxImplemented,
        dot11HEPuncturedPreambleTxActivated,
        dot11HEPuncturedPreambleRxImplemented,
        dot11HEPuncturedPreambleRxActivated,
        dot11HEDeviceClass,
        dot11HELPDCCodingInPayloadImplemented,
        dot11HELPDCCodingInPayloadActivated,
        dot11HESUPPDUwith1xHELTFand0point8GIlmplemented,
        dot11HESUPPDUwith1xHELTFand0point8GIActivated,
        dot11HESUPPDUwith4xHELTFand0point8GIlmplemented,
        dot11HESUPPDUwith4xHELTFand0point8GIActivated,
        dot11HENDPwith4xHELTFand3point2GIImplemented,
        dot11HENDPwith4xHELTFand3point2GIActivated,
        dot11HESTBCTxImplemented,
        dot11HESTBCTxActivated,
        dot11HESTBCRxImplemented,
        dot11HESTBCRxActivated,
        dot11HEDopplerImplemented,
        dot11HEDopplerActivated,
        dot11HEDCMImplemented,
        dot11HEDCMActivated,
        dot11HEFullBWULMUMIMOImplemented,
        dot11HEFullBWULMUMIMOActivated,
        dot11HEPartialBWULMUMIMOImplemented,
        dot11HEPartialBWULMUMIMOActivated,
        dot11HEPartialBWDLMUMIMOImplemented,
        dot11HEPartialBWDLMUMIMOActivated,
        dot11HEULMUPayloadImplemented,
        dot11HEULMUPayloadActivated,
        dot11HEPowerBoostFactorImplemented,
        dot11HEPowerBoostFactorActivated,
        dot11HEPartialBWERSUPayloadImplemented,
        dot11HEPartialBWERSUPayloadActivated }
    STATUS current
    DESCRIPTION
        "Attributes that configure the HE PHY."
    ::= { dot11Groups <ANA> }
```

Change the dot11Compliance object as follows:

```
dot11Compliance MODULE-COMPLIANCE
    STATUS  current
    DESCRIPTION
        "The compliance statement for SNMPv2 entities that implement the IEEE
        802.11 MIB."
    MODULE  -- this module
```


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```
MANDATORY-GROUPS {
   dot11SMTbase12,
   dot11MACbase3,
   dot11CountersGroup3,
   dot11SmtAuthenticationAlgorithms,
   dot11ResourceTypeID,
   dot11PhyOperationComplianceGroup2 }

GROUP dot11PhyDSSSComplianceGroup
DESCRIPTION
   "Implementation of this group is required when object dot11PHYType is
   dsss.
   This group is mutually exclusive to the following groups:
   dot11PhyIRComplianceGroup
   dot11PhyFHSSComplianceGroup2
   dot11PhyOFDMComplianceGroup3
   dot11PhyHRDSSSComplianceGroup
   dot11PhyERPComplianceGroup
   dot11PhyHTComplianceGroup
   dot11DMGComplianceGroup
   dot11PhyVHTComplianceGroup
   dot11PhyTVHTComplianceGroup
   dot11PhyS1GComplianceGroup
   dot11PhyHEComplianceGroup"

GROUP dot11PhyOFDMComplianceGroup3
DESCRIPTION
   "Implementation of this group is required when object dot11PHYType is
   ofdm.
   This group is mutually exclusive to the following groups:
   dot11PhyIRComplianceGroup
   dot11PhyFHSSComplianceGroup2
   dot11PhyDSSSComplianceGroup
   dot11PhyHRDSSSComplianceGroup
   dot11PhyERPComplianceGroup
   dot11PhyHTComplianceGroup
   dot11DMGComplianceGroup
   dot11PhyVHTComplianceGroup
   dot11PhyTVHTComplianceGroup
   dot11PhyS1GComplianceGroup
   dot11PhyHEComplianceGroup"

GROUP dot11PhyHRDSSSComplianceGroup
DESCRIPTION
   "Implementation of this group is required when object dot11PHYType is
   hrdsss.
   This group is mutually exclusive to the following groups:
   dot11PhyIRComplianceGroup
   dot11PhyFHSSComplianceGroup2
   dot11PhyDSSSComplianceGroup
   dot11PhyOFDMComplianceGroup3
   dot11PhyERPComplianceGroup
   dot11PhyHTComplianceGroup
   dot11DMGComplianceGroup
   dot11PhyVHTComplianceGroup
   dot11PhyTVHTComplianceGroup
   dot11PhyS1GComplianceGroup
   dot11PhyHEComplianceGroup"

GROUP dot11PhyERPComplianceGroup
DESCRIPTION
   "Implementation of this group is required when object dot11PHYType is ERP.
   This group is mutually exclusive to the following groups:
   dot11PhyIRComplianceGroup
```

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```
        dot11PhyFHSSComplianceGroup2
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyHTComplianceGroup
        dot11DMGComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyS1GComplianceGroup
        dot11PhyHEComplianceGroup"

    GROUP dot11PhyHTComplianceGroup
    DESCRIPTION
        "Implementation of this group is required when object dot11PHYType has the
        value of ht.
        This group is mutually exclusive to the following groups:
        dot11PhyIRComplianceGroup
        dot11PhyFHSSComplianceGroup2
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11DMGComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyS1GComplianceGroup
        dot11PhyHEComplianceGroup"

    GROUP dot11PhyVHTComplianceGroup
    DESCRIPTION
        "Implementation of this group is required when object dot11PHYType has the
        value of vht.
        This group is mutually exclusive to the following groups:
        dot11PhyIRComplianceGroup
        dot11PhyFHSSComplianceGroup2
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11DMGComplianceGroup
        dot11PhyHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyS1GComplianceGroup
        dot11PhyHEComplianceGroup"

    GROUP dot11PhyTVHTComplianceGroup
    DESCRIPTION
        "Implementation of this group is required when object dot11PHYType has the
        value of tvht.
        This group is mutually exclusive to the following groups:
        dot11PhyIRComplianceGroup
        dot11PhyFHSSComplianceGroup2
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup
        dot11DMGComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyS1GComplianceGroup
        dot11PhyHEComplianceGroup"

GROUP dot11PhyS1GComplianceGroup
DESCRIPTION
```


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```
        "Implementation of this group is required when object dot11PHYType has the
        value of s1g.
        This group is mutually exclusive to the following groups:
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup
        dot11DMGComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyHEComplianceGroup"

    GROUP dot11PhyHEComplianceGroup
    DESCRIPTION
        "Implementation of this group is required when object dot11PHYType has the
        value of HE.
        This group is mutually exclusive to the following groups:
        dot11PhyIRComplianceGroup
        dot11PhyFHSSComplianceGroup2
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup
        dot11DMGComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyS1GComplianceGroup"

    GROUP dot11DMGComplianceGroup
    DESCRIPTION
        This group is mutually exclusive to the following groups:
"Implementation of this group is required when the object dot11PHYType is dmg.
This group is mutually exclusive to the following groups:
        dot11PhyIRComplianceGroup
        dot11PhyFHSSComplianceGroup2
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyS1GComplianceGroup
        dot11PhyHEComplianceGroup"
```

Insert the following after GROUP dot11VHTMACAdditions:

```
    GROUP dot11HETransmitBeamformingGroup
    DESCRIPTION
        "The dot11HETransmitBeamformingGroup group is optional."

    GROUP dot11HEComplianceGroup
    DESCRIPTION
        "The dot11HEComplianceGroup group is optional."
```

Change OPTIONAL-GROUPS as follows:

```
-- OPTIONAL-GROUPS {
    -- dot11SMTprivacy
    -- dot11MACStatistics,
    -- dot11PhyAntennaComplianceGroup,
    -- dot11PhyTxPowerComplianceGroup,
    -- dot11PhyRegDomainsSupportGroup,
```

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```
    -- dot11PhyAntennasListGroup,
    -- dot11PhyRateGroup,
    -- dot11MultiDomainCapabilityGroup,
    -- dot11PhyFHSSComplianceGroup2,
    -- dot11RSNAadditions,
    -- dot11OperatingClassesGroup,
    -- dot11Qosadditions,
    -- dot11RMCompliance,
    -- dot11FTComplianceGroup
    -- dot11PhyAntennaComplianceGroup2,
    -- dot11HTMACadditions,
    -- dot11PhyMCSGroup,
    -- dot11TransmitBeamformingGroup,
    -- dot11VHTTransmitBeamformingGroup,
    -- dot11PhyVHTComplianceGroup,
    -- dot11VHTMACAdditions,
    -- dot11TVHTTransmitBeamformingGroup,
    -- dot11PhyTVHTComplianceGroup,
    -- dot11HETransmitBeamformingGroup,
    -- dot11PhyHEComplianceGroup,
    -- dot11HEComplianceGroup,
    -- dot11WNMCompliance}
```

Insert the following after dot11S1GCompliance:

```
-- ************************************************************************
-- * Compliance Statements - HE
-- ************************************************************************
dot11HECompliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "This object class provides the objects from the IEEE 802.11
        MIB used to operate at high efficiency."
    MODULE -- this module
    MANDATORY-GROUPS { dot11PhyHEComplianceGroup, dot11PhyTxPowerCompliance-
        Group2, dot11HETransmitBeamformingGroup, dot11HEComplianceGroup }
-- OPTIONAL-GROUPS { }
    ::= { dot11Compliances 22 }
```


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Annex G

(normative)

Frame exchange sequences

Insert a new subclause as follows:

G.5 HE sequences

ht-txop-sequence = he-nav-protected-sequence |
1{initiator-sequence};

(* an he-nav-protected-sequence consists of setting the NAV, performing one or more initiator-sequences and then resetting the NAV if time permits *)

he-nav-protected-sequence = he-nav-set 1 {initiator-sequence} [resync-sequence];

(* This is the sequence of frames that establish protection use MU-RTS *)

he-nav-set = (**MU-RTS**[+HTC] n{**CTS**[+HTC]}) |
(**Data**[+HTC]+*individual*[+*null*][+*QoS*+*normal-ack*] **Ack**) |
(**Data**[+HTC]+*individual*[+*null*][+*QoS*+*block-ack*] **Ack**) |
Data+*group*[+*null*][+*QoS*]

(* Only Trigger frame sequence is defined here. It can be used for all Trigger frame variants. *)

(* Trigger frame is sent by the AP to initiate non-AP UL transmission. A PPDU containing a trigger is either a non-A MPDU trigger frame, or an A MPDU containing carrying trigger frame *)

he-mu-sequence = MU-RTS-CTS-protected-sequence | he-mu-sequence-no-protection

MU-RTS-CTS-protected-sequence = {**MU-RTS** + **CTS**} + *he-mu-sequence-no-protection*

he-mu-sequence-no-protection = *dl-mu-sequence* | *ul-mu-sequence* | *cascading-mu-sequence*

(**Trigger**) | (**Trigger** +*a-mpdu* + *mu-user-respond* + *a-mpdu-end*)
1{**Data**[+*HTC*]+*QoS*+(*no-ack* | *block-ack*)+*a-mpdu*}
+ *a-mpdu-end*;
[+*mu-user-respond* other-users];

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